THE TRUCK SIMULATOR –
A TRAINING OPTION FOR THE NEW ZEALAND HEAVY VEHICLE INDUSTRY?

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Abstract

There are many reasons why both transport companies and the government should consider training as an important adjunct to their operational thinking. These include, but are not limited to; safety, efficiency, economy and career pathways.

The training paradigm has seen major shifts with the evolution of the motor vehicle. This dissertation will look at the development of the simulator as a tool, the literature that has evolved from this development, how this tool may be utilised and whether this technology has a future in New Zealand as a legitimate training aid.

While there are several different simulators in New Zealand, there currently is no dedicated truck simulator employed in training institutions in this country.

This situation is expected to change if DECA Ltd brings their simulator in from America later in 2009 as indicated.

Overseas evidence has shown that simulators can provide many benefits in the fields of fuel economy, safety awareness and fatigue reduction.

There has been interest shown in this technology from government, Ministry of Defence and industry at various presentations by the manufacturer over the past two years. The author was fortunate to be able to visit Australia and see first-hand how effective this technology can be in the hands of an experienced trainer. There will need to be similar developments in trainer expertise here before the full benefits of any simulator introduced into the New Zealand training paradigm will reach peak efficiency.

To enable industry to benefit fully from this technology, any results that accrue from training carried out in a simulator must be disseminated to the wider training fraternity and industry as a whole.

The author is of the opinion that this technology will benefit the transport industry but there will need to be much more in-depth study of both the simulator itself and the results it obtains.

1.0 The Importance of Training

1.1 Introduction

Why should training be considered one of the most important aspects of a government or a transport company's portfolio of cost-cutting measures?

One of the answers to this may come from Dean Newell, Vice President for Safety at Maverick Transportation, one of the USA's leading flatbed and glass carriers operating over 1500 trucks throughout the USA and Canada. He says that; "*An average driver makes 160 driving decisions for each mile that they drive. That's 80,000 decisions during the course of a normal 500-mile run."* (Newell Unknown)

If this is the case then training should be at the forefront of any agenda to ensure the decisions that drivers make are, for the most part, the correct ones and that any training regimes put into place for heavy vehicle drivers are the most efficient and effective for the investment in time and effort.

There are many other reasons why both transport companies and the government should consider training as an important adjunct to their operational thinking. These include, but are not limited to; safety, efficiency, economy, and career pathways.

The purpose of this research is to establish, by looking at the results obtained with overseas companies who have embraced simulator training, whether the introduction of driver simulator technology into New Zealand could benefit the transport and the transport training industries.

1.2 Safety

Road safety is a major concern for both government and the transport companies alike. Initiatives to reduce truck crashes to enhance the truck driver's safety and the safety of all the other road users will have a significant benefit to country as a whole.

Road crashes, in total, cost New Zealand approximately $4.5 billion dollars per year (Ministry of Transport 2008) with the cost for each truck accident being correspondingly greater per unit accident than that for a car crash. The consequences of this can be very severe with the subsequent impacts on company profitability and, indeed, survivability.

Bad driving in trucks has a major impact on how other traffic responds. If the negative psychological effect of these drivers on other road users can be minimised by more effective training for truck drivers, the flow-on effects of less distractions, fatigue and accidents in the general driving population will have a direct effect on the road toll and the component costs of such accidents such as insurance, ACC charges, personal and company costs.

1.3 Efficiency and Economy

In terms of national efficiency and economy, if effective training is put into place, there will be an immediate effect on aspects such as fuel economy, as empirical overseas evidence would suggest. (Referred to in depth later in this paper)

With more efficient and economical use of our fuel resources comes the ability to minimise fuel imports and to offset some of the country's carbon footprint and the possibility of increasing future carbon trading credits.

For the transport company, the benefits are very real. Better trained drivers ensure much less wear and tear on equipment thus reducing breakdown downtime, less fatigue related incidents and less damage to freight, all of which are major cost factors to the industry. Driver retention is also enhanced with all its benefits such as not having to re-train new drivers frequently with associated losses in productivity.

The downside to this is the reluctance of some companies to train their drivers only to have them enticed to move on almost immediately and the company loses the benefits of that training. Companies also need to contend with the attitude of drivers who have been in the industry for some time and are under the impression that training is not for them and they will not learn anything useful from it.

1.4 Career Pathways

Tranzqual Industry Training Organisation (ITO) is the industry standards setting body for the transport industry. One of its tasks is to "Set transport and logistics standards by engaging with our industries and developing relevant, up-to-date national qualifications." (Tranzqual 2009)

The introduction of Unit Standard based training, National Certificates, Diplomas, and postgraduate degrees have all helped to lift the industry profile. The rewards for the drivers are seen through preference being given to them when assigned to better equipment, and formal qualifications and recognition for their skills in the form of better remuneration. (Evans 2009)

1.5 Roading Costs

If crashes are minimised and driving techniques are improved, the damaging effect of heavy vehicles on the nation's roads can be reduced significantly with the obvious savings in maintenance and the ability for those savings to be funnelled into new and better roads and technology.

1.6 Summary

Driver training needs to begin at the very basic level for all novice drivers regardless of the class of licence sought.

Currently, if the novice driver wishes at some point in their driving career to drive heavy trucks, there is no mandated training regime. This begs the question; should licence training and testing for all grades of licence be more rigorous? Indeed, should the time involved in training increase as the complexity of the task increases? This suggests that training is an on-going need as driver's move into driving more complex rigs and new equipment is inserted into New Zealand's heavy transport fleets.

If more comprehensive and continuous improvement is to become the norm then the need for qualified trainers will increase proportionately as will the demands on their time. A training system such as the truck simulator may enhance the ability to meet the requirements of all or part of these questions. For these reasons alone this avenue should be explored.

Training technology has developed significantly with the advent of new communication methods such as the use of computer based presentation techniques. There is now the ability to take training to the job site electronically and to use tools such as the "Stability Control" tanker unit in use now with Master Drive Services Ltd.

Figure 1: Master Drive "Stability Control Tanker"

Source: Master Drive Services Ltd

Truck simulators which are in use in many parts of the world and (as reported by the Truck and Driver Magazine in August 2008) are scheduled to be introduced into the New Zealand driver training paradigm sometime in 2009-10 (Unknown 2008) may provide a further option for the heavy vehicle trainer.

2.0 Literature Review

2.1 Introduction

People have been using simulation as a learning tool since time immemorial. This ranges from the sand models used in early Egypt to the latest sophisticated Inter Vehicle Information Systems (IVIS) used to full effect by the US Army in the first Gulf War and the full motion aircraft and truck simulators in use internationally. Ever since the powered vehicle came into existence and drivers needed to be trained to operate them, the simulator has grown in importance and sophistication.

The training paradigm has seen major shifts with the evolution of the motor vehicle. This dissertation will look at the development of the simulator as a tool, the literature that has evolved from this development, how this tool may be utilised and whether this technology might have a future in New Zealand as a legitimate training aid.

This chapter deals with;

- A short history of the simulator
- The research vs. the training simulator
- The different types of simulator
- Simulators currently in use in New Zealand
- What the Governments stance is on simulators
- The simulator trainer and
- A look at what a simulator might cost.

2.2 A Short History of Simulators

Simulators as we know them today came into being before the Second World War and were originally used for military training for teaching personnel to use tanks, aircraft and ships safely. They were utilised in an attempt to reduce operational costs to real equipment while still preserving the integrity of the training involved. (Morrison 1991)

The two schools of thought prevalent at the time were; "A design of a simulator with high fidelity (i.e. the more a training device is like the criterion device the better it will be, or a design of a simulator that is "as phony as can be" without compromising training effectiveness". (Roberts 1980)

2.3 Types of simulators

2.3.1 Research vs. Training

The author's initial thinking was that there would be a significant amount of research for both the simulators that have been developed initially for research and those developed with training as their primary function. This has proved not to be the case.

There is a large amount of research available on simulators used solely for research; in fact Google Scholar lists approximately 56,400 articles when the search parameter 'research driver simulator' is entered. If "training with simulators" is entered there is a similar response, about 67,000 entries, but a look at the first few pages brings up every other field of research other than driver training. Insertion of the word 'driver' reduces this to around 24,000 entries but further investigation reveals that most of the articles are still concerned with research as against training in a more structured form.

Yoshimoto and Suetomi (2008) noted that the first three major driving simulators developed in Japan in the 1960's and 1970's were primarily for research and development and the first traffic safety training simulator was developed by the National Police Agency in the late 1960's and; "successfully deployed for training of traffic act offenders and novice trainees; (Yoshimoto 2008)

Wierwille and Fung (1975) stated that a "Research simulator would be useful in establishing the essential part-task requirements for simulator applications that require simplicity and low cost e.g. driver education and training." (Wierwille and Fung 1975) Even though training simulators are becoming more accessible as technology allows better interaction between the trainee and the simulator, the original uses by the military for training personnel to operate equipment instead of the real thing to avoid extremely hazardous circumstances following loss of control, it follows that there are now many modern driver training applications that can be adapted for the simulator.

There is, however, a perception that there is insufficient literature on this aspect of simulator use. Blana (1996) suggests that; "A significant research program, including studies of the transfer of training to real world conditions will be required to validate the effectiveness of simulator training for driver education." (Blana 1996)

2.3.2 Variations of Simulator Type

As far as New Zealand is concerned the simulators investigated range from the simple PC based simulator used to assist Occupational Therapists (OT) in helping rehabilitate drivers whose licences have been suspended because of injury to the advanced truck simulator that Deca Training proposes to set up in Auckland.

The PC simulator was developed in the 1980's to allow OT's to test cognitive responses to traffic situations and the responses to safety signage before allowing the driver back on the road for final appraisal (Gianutsos 1991). Whilst this technology is not new and there are developments in train to allow better diagnosis, it is still a useful tool for the OT's to have in their arsenal to assist with the decision whether to allow an impaired driver back on the road.

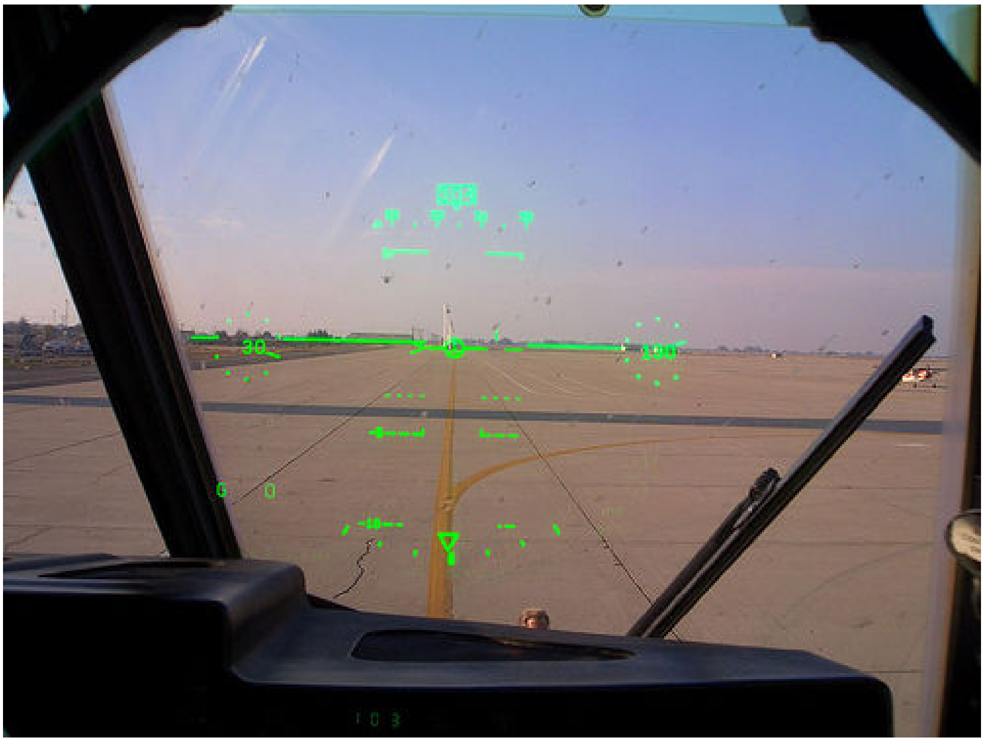
The other simulators looked at in this paper range from the Head-up display through the sophisticated IVIS system available to the US military to the truck simulator

A **Head-Up Display**, or simply **HUD**, is any type of display that presents data without blocking the user's view. This technique was pioneered for military aviation and is now used in commercial aviation, motor vehicle and other applications.

HUDs have in common the following characteristics:

- The display element is largely transparent, meaning the information is displayed in contrasting superposition over the user's normal environment.
- The information is projected with its focus at infinity. Doing this means that a user doesn't need to refocus his eyes (which takes several tenths of a second) when changing his attention between the instrument and the outside world. (Wikepedia 2009a)

Figure 2; C-130J Co Pilot's Head-up display



Source:http://en.wikipedia.org/wiki/File:C-130J_Co_Pilot's_Head-up_display.jpg

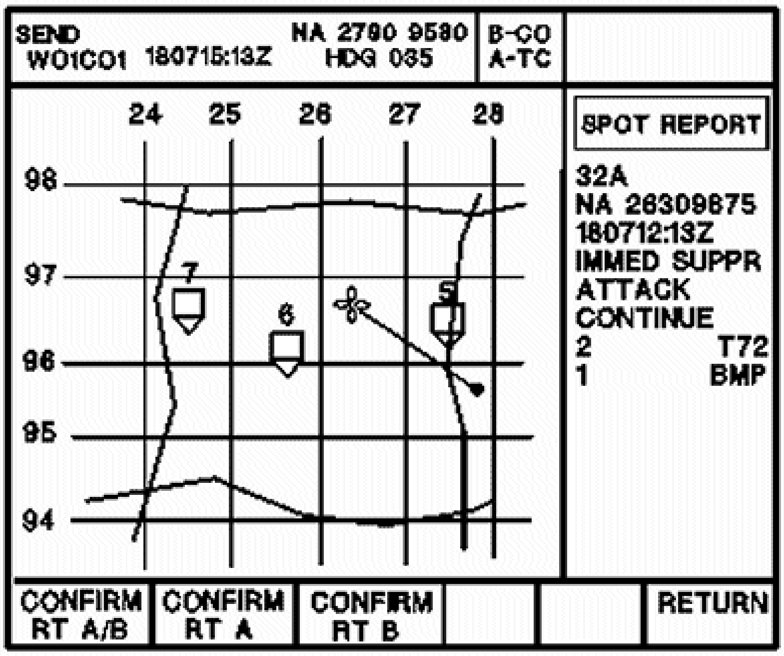
Chisholm et al (2008) utilised the HUD as part of her research into intersection behaviour;

"An experimental study was conducted to determine if intersection behaviour of those 18 to 24 and 65+ benefited from advanced in-vehicle signs presented in a head-up display (HUD) format. The University of Calgary Driving Simulator (UCDS) was used to determine whether intersection performance improved in the presence of several advanced signs or whether unwanted adaptive behaviours occurred (e.g., increasing speed to run the light instead of stopping). In-vehicle signs facilitated an increase in stopping occurrences for both younger and older drivers at intersections with relatively short yellow onsets." (Chisholm 2008)

Chisholm contends that the use of the HUD in this study showed that, in both age groups studied, there was a significant improvement in the number of stops at late amber lights. She also concluded that Intelligent Transport Systems (ITS) such as the HUD have been identified as being of benefit to drivers but have not been extensively studied.

The United States Army uses a system called IVIS (Inter Vehicle Information System) to share battleground information with their generals and battlefield commanders on the ground to enable everyone to have access to the same up-to-date information allowing them to make informed and timely battlefield decisions without having to rely on second-hand or out of date information. The proverbial story from WW1 about the relayed request to "Send reinforcements, enemy advancing on the west flank" turning into "Send 3 and 4pence, enemy dancing on a wet plank" shows how communication at this level can win or lose battles and indeed, wars. Figure 3 shows what the tank commander would see when a request for suppression fire was received on his monitor.

Figure 3: IVIS SPOTREP (immediate suppression request).



Source: http://www.globalsecurity.org/military/library/policy/army/fm/17-15/chp6.

<u>2.3.3 Truck Simulators</u>

Europe and the USA have had successful truck simulators for several years with most of the major manufacturers being represented either with their own company simulators, or by having their trucks used by commercial producers. Volvo has their own; FAROS use the Renault VI Magnum, TruckSim in the UK use the Mercedes Actros cab and successfully launched their fully integrated simulator in October 2003. (Parkes and Rau 2004)

The Trucksim simulator was tested by over 600 trainees from November 2003 to March 2004 in an evaluation period to ascertain the value of this form of training and the results were summarised as follows:

> "In terms of the various training exercises, it was those that focus on the tactical level of driving (fuel efficiency, poor weather driving techniques, adapting to different load

conditions such as liquid or hanging, or responding to emergency situations such as a tyre blowout) that were deemed the most effective. Exercises that focused more on the operational control level, such as low speed parking manoeuvres, were seen to have less of an advantage over traditional training in a real vehicle, and would require more development before being seen as a viable alternative. There was a strong favourable response from both the drivers and their transport managers towards the potential of synthetic training for both license acquisition and professional development training for truck drivers. The next steps in the research should be to investigate the cost efficiency of synthetic training in relation to current on-road training; and to establish whether the transfer effects from synthetic training are as sustainable via the use of longitudinal follow-up studies." (Parkes 2004 b)

Some simulators, like the National Advanced Driver Simulator in Iowa USA – considered by many to be the most advanced simulator available, given its complexity, could probably not easily be inserted into most training environments because the cost would be prohibitive. (Parkes and Rau 2004)

Strayer and Drews (2002) presented a paper on the use of computer simulation in relation to fuel management training. Drivers completed a 2-hour fuel management training course developed and delivered by GE Driver Development. The course comprised 19% lecture, 24% computer-based training, and 57% simulator training. Simulator training was administered on the GE TranSim VS™ simulator. Their summary of the training suggested that even with a large variance in ages, ability and experience, this form of training was both beneficial and retained.

"In summary, these data provide strong validation for the GE Driver Development fuel management program. The benefits of training are significant, appear to be sustained over time, and tend to benefit most those drivers whose performance was initially below the median on fuel efficiency. Drivers' age and tenure did not affect the efficiency of the training. Cost-benefit analysis suggests that simulator-based training provides a very effective means of reducing operating expenses for commercial trucking, particularly for less skilled drivers." (Strayer 2002)

2.4 Simulators Currently in use in New Zealand

The three main simulators in use in New Zealand are;

- Waikato University's TARS simulator
- SimDrive's public driving simulators and
- DECA Training's about to be introduced TranSim VS IV™

Waikato University's Traffic and Road Safety (TARS) Research Group which was founded in 1993, have;

> "established a state-of-the-art research capability which includes innovative technologies for field study of behaviour as well as the most advanced driving simulator laboratory in New Zealand." (Waikato University 2008)

SimDrive Ltd is;

> "rolling out driving simulators throughout New Zealand. Each is located in a shopping centre, and one will be opening near you." (de Hamel 2008)

Precision Training Ltd (2008) mentioned in a press release that DECA Training is proposing introducing a truck simulator to Auckland;

> "Stu Stubbs, the Managing Director of DECA Training was also pleased to advise that as part of this exciting initiative, DECA Training will be introducing a Heavy Vehicle Driver Training Simulator to New Zealand. This highly capable, trailer

> mounted training aid will be able to travel throughout the country" (Precision Training Ltd 2008)

Subsequently, Stubbs reported that the simulator will not be in New Zealand for at least another six months owing to issues in Australia and the US dollar exchange rate. (Stubbs 2009)

2.5 Government Stances on Simulator Training

Baas (2003) stated that "Current forms of driver training and education need to change to reflect the new environment the transport industry is entering." (Baas 2003). While he does not mention simulator training playing a role in this changed training environment, the previous Labour Government (1996) has noted that:

> "Driving qualifications to reflect continuous measured competence and ability in all these areas. To achieve this, simulator training will be investigated and, if practicable, instigated initially for new drivers." (Labour Government 1996)

New Zealand First mentioned in a transport policy statement:

> "(We would) ensure that driving qualifications reflect (by way of continuous measured competence) ability in the areas of the driver's knowledge, skill, experience, fitness and attitude. To achieve this, simulator training will be investigated and where practical instigated" (Brown Unknown)

Skellern (2008) also noted about the Bay of Plenty Polytechnic that;

> "The (Bay of Plenty) Polytechnic has been running road transport courses for nearly six years, and it has been talking with industry training organisation Tranzqual about widening the programme to include warehousing, freight forwarding, passenger bus services and stevedoring. Students at the new training centre could be taught to drive long-haul trucks and buses through the use of the internet and a simulator." (Skellern 2008)

This is in line with the polytechnics in New Plymouth and Wellington offering truck driving cadet courses in conjunction with Tranzqual.

Baas and Latto (2005) in a report prepared for the Energy Efficiency and Conservation Authority (EECA), noted as part of their recommendations;

> "It is recommended that EECA and Land Transport NZ introduce new initiatives that encourage transport operators to become more energy efficient and to encourage fuel efficient driving. Other jurisdictions have already introduced similar packages, for example the UK Road Haulage Modernisation Fund and the work of the Energy Savings Trust. In Canada the Federal Office of Energy Efficiency runs the Fleetsmart and Smart Driver Programmes and in the USA there is the Smartway Transport partnership, a voluntary programme run by the US Environmental Protection Agency.
>
> The main elements of a New Zealand operator-focused programme should include:
>
> - Energy efficient driver training
> - Increasing skills and awareness amongst operators on how to monitor and minimise fuel consumption. This could be through the development of a package that includes case studies, fuel management guides and other material similar to that produced by the UK Transport Energy Best Practice programme.
> - Freight logistics reductions in freight travel demand. (Baas 2005)

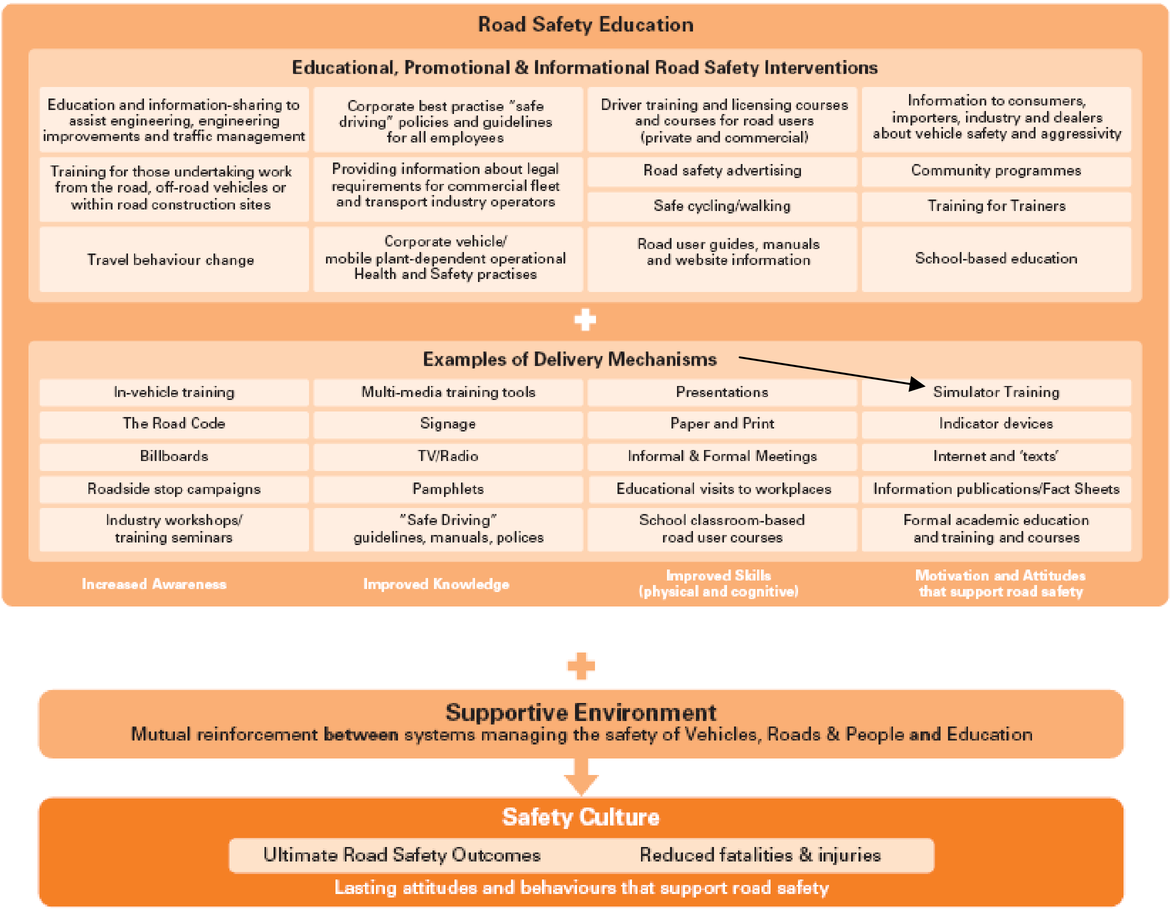
Although the UK initiative mentioned above incorporates simulator use and there is extensive coverage of the UK developments in their report, there is no mention of the use of this technology by Baas and Latto (2005) in any of their recommendations. Any reference to training simply implies that more fuel-efficient training should be carried out but does not give any indication of how this might be achieved.

If New Zealand is to move towards a goal of utilising its fuel resources better then, surely, any initiatives that have seen positive results overseas should be put to stakeholders as an alternative for study.

The "Road Safety Education Strategic Framework" (Figure 4) cites simulators as one of the; 'Examples of Delivery Mechanisms' in facilitating Road Safety Education but little more is said in this document as to how this might be implemented (National Road Safety Committee 2006).

Duynhoven (2008) says that the government of the time was more concerned with reducing the road toll and that simulators were not on the radar as driver training was not considered as part of the road toll reduction process. (Duynhoven 2008)

Figure 4: Examples of road safety education interventions and delivery mechanisms



Source: Road Safety Education Strategic Framework

The New Zealand Transport Agency (NZTA) is a "Crown entity established on 1 August 2008, bringing together the functions of Land Transport New Zealand and Transit New Zealand to provide an integrated approach to transport planning, funding and delivery." (New Zealand Transport Agency 2009)

Furneaux (2009) from (NZTA) reports that; "At the moment NZTA does not have any particular policy on the use of simulators, other than recognising that we need to make ourselves aware of the advances in technology and how that might be able to be used within areas of driver training and testing." (Furneaux 2009)

He goes on to say; "In the last 12 months, I have had far more correspondence regarding simulators and computerised training aids than for the whole of the last six years, so we are certainly looking at this with a great deal of interest." (Furneaux 2009)

Parkes (2003) reported on the current thinking in Europe where the European Commission Directive on Training for Professional Drivers dictates the minimum basic and advanced training regimes for professional heavy vehicle drivers. These range from 35 hours of re-training every 5 years to basic training of 240 hours, both of which can include simulator components. (Parkes 2003)

It would appear that while the government is concerned with road safety, fuel efficiency and, to some small degree, driver training to make these goals possible, they seem to have the idea that training is not the way to achieve any of these objectives if a blog posted in 2006 on the SAFEAS Road Safety Discussion website would have us believe;

Road Safety discussion => Other road safety discussion => Topic started by: Squeak on July 31, 2006, 09:58:41 am

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Title: **Driver Training**

Post by: **Squeak** on **July 31, 2006, 09:58:41 am**

The Ministry of Transport believes that driver training does not make a significant reduction in serious crashes or the road toll. Yet why do most of us believe this to be false? I have a couple of thoughts and hypothesis on this….

Driver training is traditionally applied after the person has started learning to drive. Most drivers in NZ get trained by mum or dad thereby learning their bad habits. If the right skills and habits aren't learned upfront then they need to be unlearnt. Unlearning via training is exponentially more difficult than learning it right first time.

Another aspect is attitude. New Zealand is a nation of drivers. We believe that it is our right to drive on the roads, which may in part explain the large number of unlicensed drivers. A driver may have the right skills but have the wrong attitude (e.g., too aggressive or too cautious). And again, this attitude can be learnt from whoever teaches the student.

It is also far too easy to get your licence in this PC country where no one is allowed to fail. It is very common in the UK for people to fail their test. I would expect a 25% failure rate, though this shouldn't be a target – the test should be designed to really test the driver. As per aviation testing you need to put the student under a little pressure to see how they react.

And once people have the right skills and attitudes they then need to be maintained. It is commonly held-perception that the government will not bring this in because it will force a large percentage of the aging population off the road and therefore lose votes. How serious are we really about road safety?

My conclusion?

The belief that training does not matter is based on flawed and ineffective training models. Training needs to start at the very beginning of a person's driving career. And if people are not able to maintain a level of competency then we should remove them from our roads.

My recommendations?

- Professional driver training for new drivers before they even get behind the wheel. Learner drivers can only drive with an instructor. This could either be compulsory, or an incentive could be used, such as a quicker path to full license.
- Training and testing should include "soft" skills such as road etiquette (e.g. consideration).
- Make it difficult to get a drivers licence.
- Regular re-testing or training. If you can't re-pass the test then you shouldn't be on the road.

(Road Safety Discussion Forum 2006)

Perhaps the government should read some of these blogs – and the related answers – and attempt to put some of these ideas into practice or at the very least put them forward for future study.

2.6 The Trainer

There are a myriad of "Train the Trainer" courses ranging from 'how to train your cat' to training for higher management.

As far as training operators for simulators, a report by Brock et al (2001) noted that a critical feature in the success of simulator training programs is the competence and enthusiasm of the instructional staff. (Brock 2001)

So far, the author's enquiries in New Zealand have not revealed any source of training for operators of simulators for driver training.

The Taranaki Driver Assessment Centre (TDAC) which owns and operates the PC based simulator referred to in 2.1.2 pg 2 of this report is aware the various OT's that have used the system have been taught how to use the simulator by the previous incumbent. While this experience is invaluable in the initial stages, there is no formal training available for this system. This lack of training could possibly limit the usefulness of this device to the patient being assessed and further research could look at whether this could carry over to any other form of simulator introduced into New Zealand.

2.7 The Cost

A very real consideration for introducing a simulator of any description to New Zealand would be the initial cost of the system and its ongoing maintenance costs. Added to this would be the costs of training operators to the required level, premises – or mobile operating costs, and advertising.

Allen and Tarr (2005) evaluated five different simulator packages and their costs (Table 1).

They were;

Table 1: Simulators evaluated 2005 (Allen and Tarr 2005)

Level	Configuration	Cost - $US
Level 1	PC simulator with joystick configuration	$6,000
Level 1	FAAC Rabbit Simulator	$25,000
Level 2	VS2 Truck Simulator	$65,000
Level 3	Patrol Simulator	$160,000
Level 4	Mark 2 Truck Driving Simulator	$500,000

The cost in each case reflected the complexity of the simulator and only its initial cost in 2005.

Olsen (1995) provides a price range that is somewhat different;

> "A wide range of (such) driving simulators exist including single-screen, non-motion based systems starting in the $40K - $80K range on up to full, motion-based systems in the multi-million dollar range. (Olsen 1995, August.)

These, and indeed any, prices researched are only an indication of what might be expected when one seeks to set up this form of technology initially.

Which simulator would be appropriate to the New Zealand paradigm has yet to be established but Strong (2009) suggests the one likely to be imported in the near future will be in the price range of approximately $US150,000. (Strong 2009)

The initial cost is by no means the only cost the would-be simulator operator would need to take into consideration. Set up, ongoing maintenance, training of staff and, if the simulator were to be mobile, the cost of providing a suitable vehicle, configuring the vehicle and the associated computer systems and running costs would also have to be factored in.

The other side to this coin is the cost to the transport operator for their drivers to attend simulator courses. The question this poses for the simulator operator is to keep the cost down to where it is affordable for the transport operator and still profitable to operate the simulator.

Coyle (2009) is of the opinion that; “My own views, based on what has taken place in the UK, is that truck simulators are not economically viable without Government financial support” (Coyle 2009).

He also raises the issue that;

> “Vehicles with modern electronically controlled engines and other electronic capabilities can now supply a massive amount of information on driving style and vehicle operation. This is usually downloaded through a Can-Bus and can be used to identify where a specific driver needs focussed training. This is also likely to be a threat to simulators, because the information can be constant, linked to incentive schemes and league tables. (Coyle 2009)

Much work would need to be done with all the various stakeholders surveyed for information, such as who would own/pay for the simulator, before any worthwhile cost-benefit analysis could be done.

2.8 Summary

There is much evidence for the simulator as a research tool but a distinct lack of empirical research as to the benefits and efficiency of this technology as an aid to training heavy vehicle drivers.

The question should also be asked as to whether the average truck driver would assimilate this level of learning. While Strayer and Drews (2002) suggested that the benefits of such training are significant and are sustained over time, this still needs to be researched empirically in New Zealand to further justify time and money being invested in this technology.

There are a number of low-cost PC based simulators on the market and while these are mainly aimed at the novice driver while they are learning to drive, the full motion simulators, e.g. Trucksim, have the ability to give much greater sensory feedback to the operator thus delivering far greater realism to the training, albeit at the cost of the occasional motion sickness.

Some of the most pressing questions to consider when contemplating introducing these newer forms of technology include whether the benefits that would be available would outweigh the cost of such a large capital investment or whether some form of co-operation would be possible with overseas interests such as the global transport companies with whom we already do business.

Whether we would be able to access technology like, either Trucksim's or the GE simulator in New Zealand via a satellite hyper reality link, or whether we would have to recreate physically the simulator here for our trainees to make use of this technology also remains a question for the future.

While any form of simulator can be a very useful tool, they are restricted to operating in the first order of communications significance, i.e. they are only as good as their programmers and can present only a specific set of parameters. They cannot incorporate the "human factor" that allows the instructor, who can think in second order significance, to introduce their own experiences to make points and, more importantly, convey conceptual ideas.

3.0 Research Methodology

3.1 Overview

This study sets out to:

1. Establish the framework of how a Heavy Vehicle driver is trained in NZ and what the different routes are by which licensing of these drivers is achieved and compare this to overseas licensing regimes.

2. Establish what, if any, training is required to meet these legislative requirements both in New Zealand and overseas.
3. Establish the benefits (or not) of introducing this technology into NZ from a training point of view.
4. Look at results obtained in overseas research as to the benefits in operational safety achieved by simulator training and how this might be incorporated into current or future legislative and/or training requirements in NZ.
5. Using these results arrive at a conclusion as to whether or not simulator training could be utilised as an option in the NZ heavy vehicle training paradigm.
6. Survey prospective New Zealand customers as to their understanding of simulator technology, its uses and relevance to them as a training tool.

3.2 Scope

3.2.1 The Licensing Process

This aspect of the study will focus on the process that the budding heavy vehicle drivers must undergo to obtain the necessary licences to enable them to be employed successfully in the industry in New Zealand and the changes that have come about over the past few years.

This will be drawn directly from the current legislation in New Zealand and compared with the same processes that are in place in other comparable countries.

3.2.2 Training Regimes.

Recently introduced rules in the New Zealand licensing industry have mandated training for one option for obtaining heavy vehicle licences for the first time in the country's history. This will be scrutinised for its efficiency in delivering its intended results and compared with similar legislative offerings from overseas.

3.2.3 Simulator Research

The findings of manufacturers and users of truck simulators overseas will be evaluated to see if there is a correlation between what has been established overseas and what could be achieved in New Zealand by the introduction of this technology.

3.3 Knowledge Limitations

While there are ample studies on the use of simulators as research tools, there is little empirical evidence to be found on their use as a pure training medium. This study will focus on one manufacturer as this will be the simulator that will probably be the first deployed on a commercial basis in New Zealand. This may have the effect of narrowing this research but will also open the field to further comparative study should another form of simulator be used as a training tool in New Zealand in the future.

4.0 The Driving Environment and the Place of Simulators

4.1 Introduction

By definition, a simulator is "Any device that simulates specific conditions for the purpose of research or operator training" (William Collins Sons & Co Ltd 1988)

This project draws on prior research in the area of research and training simulators in the transport and related industries and the current state of driver training and licensing in New Zealand.

This chapter looks at the need for drivers in New Zealand, how these drivers obtain licenses here, in Australia and in Europe. The simulator that is likely to be introduced into New Zealand is then discussed.

4.2 The Need for Drivers in New Zealand

Heavy vehicle drivers have been in short supply for some years with the Road Transport Forum (RTF) lobbying government continuously to keep the job of 'Truck driver (general)' listed on the Immediate Skills Shortage List (ISSL) and the Long Term Skills Shortage List (LTSSL). As late as June 2009 they have had only partial success with the government relenting slightly and listing drivers on the ISSL rather than the LTSSL as the Forum would wish. (Central Area Road Transport Association Inc 2009)

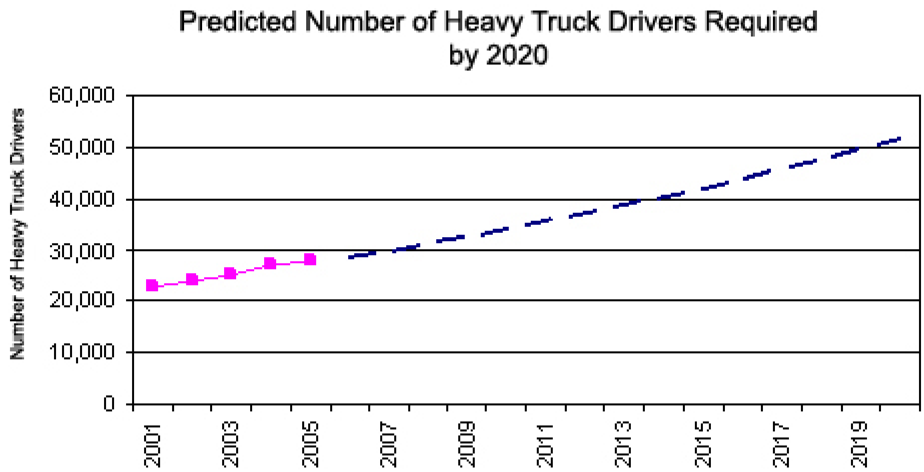
While the global economic downturn in 2009 reduced demand and therefore the need for drivers, this can be viewed as an aberration because of the predicted increases in freight haulage expected in the future.

Career Services (2008), on their website, have stated that:

> "The number of people employed as heavy truck drivers in New Zealand has been growing steadily. In 2006 there were 26,343 heavy truck drivers, up by 21% from 1996, when there were 21,783 drivers. Employers are struggling to fill these jobs. In 2007, the Department of Labour reported that just 49% of heavy truck driver jobs were filled within 10 weeks of being advertised." (Career Services 2008)

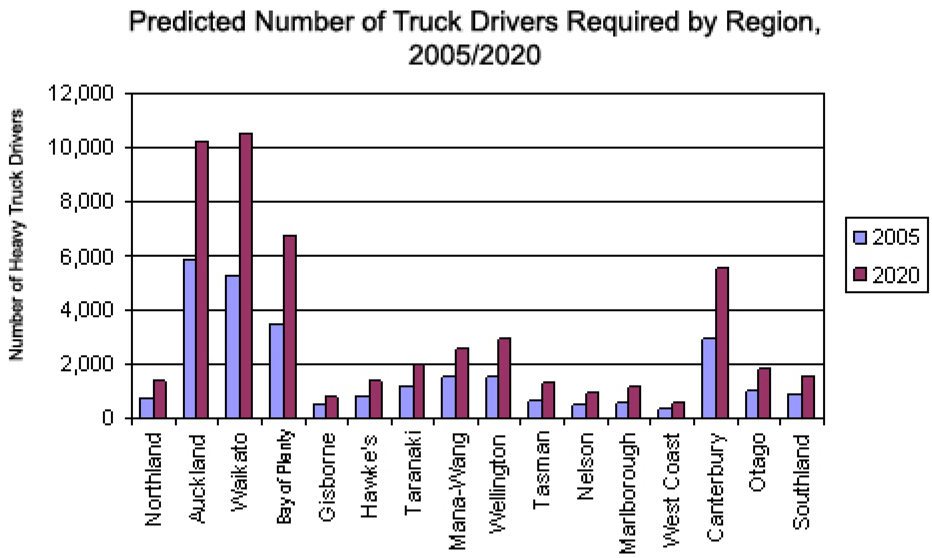
The numbers of heavy vehicle drivers required in the industry is steadily growing and the following data in Tables 2 and 3 gives an indication of this growth;

Table 2: Predicted number of Heavy Truck Drivers required by 2020



(TERNZ 2006)

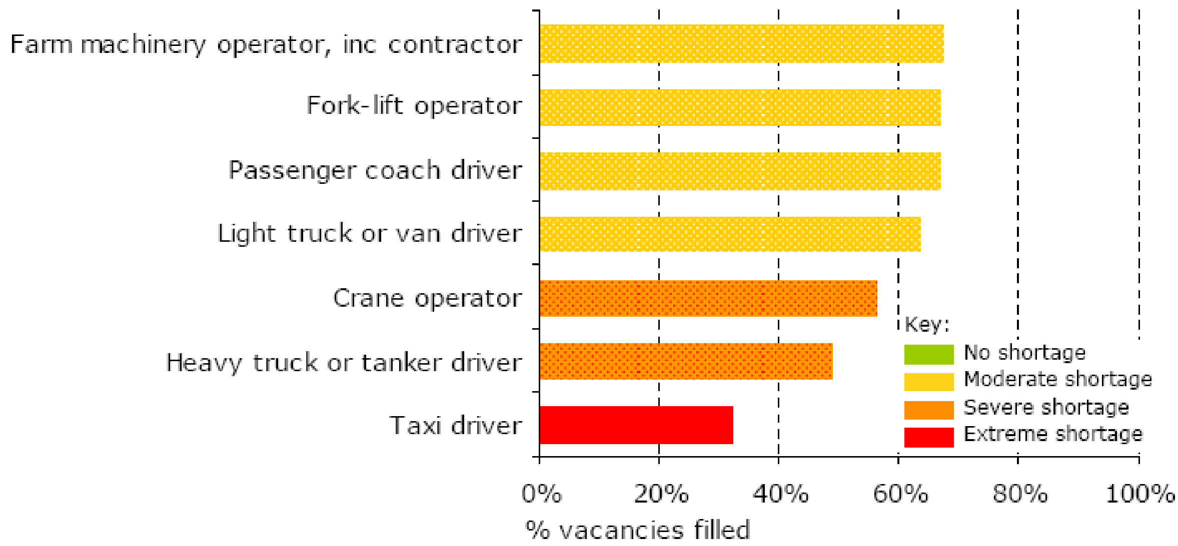
Table 3: Predicted Number of Truck Drivers required by Region 2005/2020



(TERNZ 2006)

This level of requirement is further exacerbated by the fact that empty jobs simply cannot be filled as required and there is a growing critical shortage of skilled drivers. The Department of Labour keeps statistics on the fill rates for critical occupations. (Tables 4 and 5)

Table 4: Fill rates for driver and mobile machinery operator occupations, 2007



Source: Department of Labour, 2008
Note: Occupations for which fewer than 10 employers were interviewed in the SERA are omitted from this graph.

Table 5: Fill rates for driver and mobile machinery operator occupations, 2006 to 2007

NZSCO code	NZSCO description	Fill rate		2007 vacancies	
		2006 (%)	2007 (%)	JVM (no.)	Sample (no.)
83211	Taxi driver	-	32	46	25
83212	Light truck or van driver	-	64	489	55
83221	Passenger coach driver	-	67	42	18
83231	Heavy truck or tanker driver	40	49	649	49
832	**Motor vehicle drivers subtotal**	**47**	**56**	**1,230**	**147**
83311	Farm machinery operator, including contractor	67	67	98	49
83331	Crane operator	-	56	18	16
83341	Fork-lift operator	-	67	211	21
833	**Agricultural earthmoving and other materials/handling equipment operators subtotal**	**45**	**53**	**642**	**140**
83	**Drivers & Mobile Machinery Operators total**	**46**	**55**	**1,888**	**289**

Source: Department of Labour, 2008

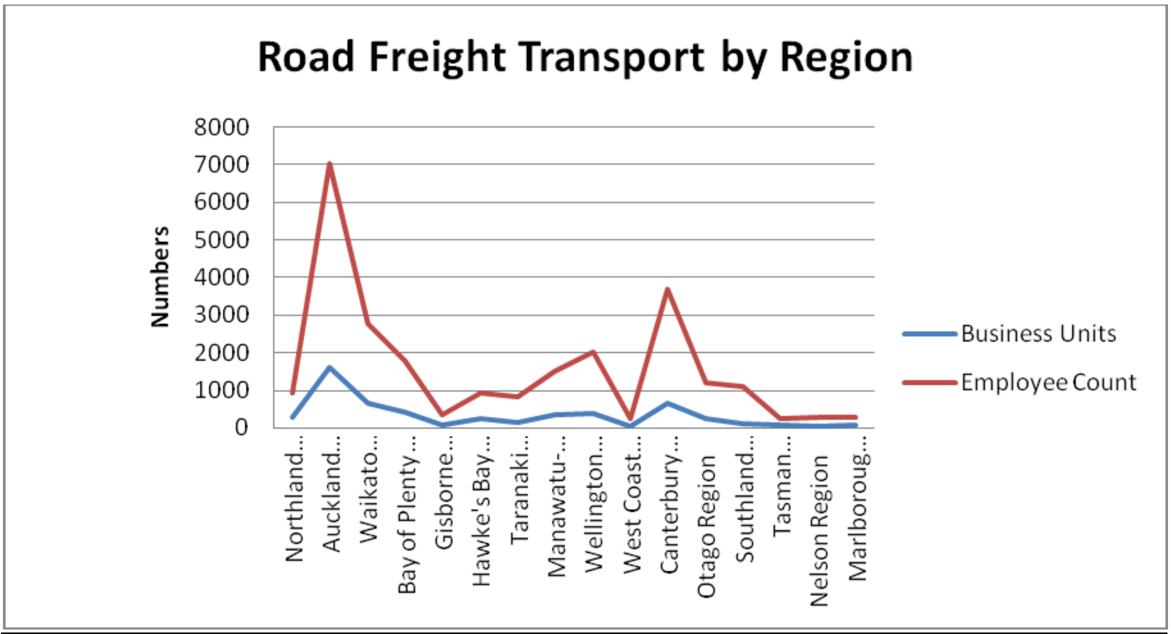
(Department of Labour 2008)

The main road transport sectors that employ heavy truck drivers are:

- general freight
- forestry
- bulk (fertilisers and construction aggregates)
- dairy
- stock
- line haulage (long distance)
- local delivery

Local and regional councils, and contractors working on their behalf, employ large numbers of heavy truck drivers. (Table 6)

Table 6: Road Freight Transport by Region



(Statistics Department 2008)

With this growing demand for skilled personnel the need to ensure they are properly trained takes on more urgency. While traditional training methods are attempting to fill the gap, now would seem the logical time to look seriously at the benefits a mobile truck simulator could bring to the industry as a whole.

4.3 Heavy Vehicle Driver Licences

4.3.1 New Zealand Licensing

For a prospective truck driver the licensing system in New Zealand can seem rather daunting as they negotiate their way from a car licence through to the Class 5 heavy trailer licence.

The Land Transport (Driver Licensing) Rule 1999 (Part 4 clauses 15 – 19) and its subsequent amendments list the ways this can be achieved. (Ministry of Transport 2007).

What is truly frightening is the fact that if a young driver begins their driving career at 15 years old, by the time they reach just over 20 years old they can hold a full class 5 heavy truck and trailer licence without undergoing any formal training whatsoever. The only criteria is that they pass a medical, pass the learner licence "scratchy" tests and undergo the full licence tests which are administered by the Automobile Association (AA) and other agencies such as Vehicle Testing New Zealand (VTNZ) on behalf of the New Zealand Transport Agency (NZTA). The only holdup to this process is to wait for the prescribed stand-down periods to expire at the learner, restricted and different licence class levels. (Ministry of Transport 2009)

If the prospective driver wishes to shorten this process, then "mandated" training takes place but only at the class 2 and class 5 level and this is restricted to one or two days of classroom training by an approved provider and enough practical training to satisfy the assessor that the candidate is competent to undergo the assessment at the end of the training phase. To obtain the class 4 licence through this scheme assessment only is required. If this woefully inadequate amount of training is combined with a Defensive Driving course at the Class 1 restricted licence level then the class 5 licence is obtainable at just over age 18 ½ . Details of this training and how it is to be administered are available in NZTA's "Statement of approval Conditions". The document states; "This document is a statement of approval conditions imposed under clause 102(2) of the Land Transport (Driver Licensing) Rule 1999 on any individual or organisation approved to conduct NZ Transport Agency (NZTA) approved driver licensing courses" (New Zealand Transport Agency 2008).

The provider adds the further dimension of Competency Based Training and Assessment to the purely Competency Based assessment applied to driver licensing by the Automobile Association (AA).

Christie (2000) argues that between the Competency Based Assessment process and the Competency Based Training and Assessment process;

> "There is little scientific evidence that competency based training and assessment (CBTA) programs produce safer and more proficient drivers than competency based assessment (CBA) systems. CBTA appears to increase costs for applicants for no apparent gain other than a community perception (misconception) that the

> novices trained and licensed under CBTA are somehow superior to those who undergo licence assessment only via CBA. Competency standards are the same under CBA and CBTA." (Christie 2000)

Christie has also found that in Australia; "Driver licensing standards largely determine what licence applicants will learn and what training and educational materials are provided – licensing standards drive training standards, not the other way round" and, possibly more importantly; "Driver training in itself has little value unless it addresses the development of competencies that must be achieved for licence qualification (or employment in the case of truck and bus drivers). There is little motivation or incentive for candidates for any class of driver licence to learn more than that required to gain a licence, permit or other certificate." (Christie 2000).

4.3.2 Australian Licensing

If one drives in Queensland (Australia) and wishes to upgrade a heavy truck licence to a multi-combination licence to allow one to drive road-trains or B-doubles – the largest type of vehicle on Australian roads – the prospective driver either sits the appropriate course or submits a "Multi-Combination Driving Experience Declaration" which states;

> "You must have held a class HR or HC provisional or open licence for at least 1 year, and have had regular and substantial driving experience on public roads in a B-double or road train.
>
> Your driving experience will be considered to be regular and substantial if it was gained on frequent segments over periods of at least 6 months. Alternatively, the licence issuing officer may accept your driving experience gained over a shorter period provided that it represents a total of at least 50 hours". (Queensland Government 1999)

It would seem that if you had the time behind the wheel and could have it verified by an employer, it would be possible to step into a very large heavy vehicle with practically no training and begin driving.

The minimum time a driver licensed to drive a car would have to wait before they could drive a Multi-Combination vehicle is only four years. If we combine the time on the learner (1 year) and provisional licences (2 years) and a start age of 16, our prospective Australian truckie would be 23 when they start their career in the larger vehicles. (Queensland Government 1999)

4.3.3 The European Regime

As previously mentioned, (sect 2.5 pg. 13) the European Commission Directive on Training for Professional Drivers dictates the minimum basic and advanced training regimes for professional heavy vehicle drivers. Parkes (2003) has summarised the European Parliament's thinking;

> The total length of full basic training is 420 hours (12 weeks of 35 hours each). For minimum basic training this will be 280 hours. Each trainee driver must drive for at least 20 hours individually in a vehicle of the category concerned. Each driver may drive for a maximum of 8 hours of the 20 hours of individual training "*…on special terrain or on top-of-the-range simulator so as to assess training in rational driving based on safety regulations, in particular with regard to vehicle handling in different road conditions and the way they change with different atmospheric conditions and the time of day or night.*" (European Parliament 2003 pg24)
>
> The new Directive goes even further. It opens the way for simulation to play a part in the practical element of the driving test. It states that the basic elements of the practical test must have duration of at least 90 minutes. This practical test may be supplemented by a test taking place on special terrain or on a top-of-the-

range simulator. *"The duration of this optional test is not fixed. Should the driver undergo such a test, its duration may be deducted from the 90 minutes….but the time deducted may not exceed 30 minutes"* (op.cit. p25)

Parkes goes on to say that every five years all HGV (Heavy Goods Vehicle) drivers should undergo 35 hours continuous training, stating that, "Such periodic training may be provided, in part, on top-of-the-range simulators". (op.cit. pg27) (Parkes 2003)

The New Zealand Government should be looking further into introducing similar regimes into our driving culture.

4.4 Simulator Training

Smith (2009), CEO of Tranzqual Industry Training Organisation, the Standards Setting Body for all transport and logistics operations in New Zealand, has this to say on simulators and the part they may play in this industry;

> "Simulator based technology is now well established across many industries, in particular aviation. In terms of road transport and driver training it's been established for some time in countries such as America, Canada and more recently Australia. The technology will be available shortly in New Zealand and while it will not have an application across all aspects of driver training it will be an important new addition to the training landscape. In some specific areas, such as fuel efficient driving, it will have a very important part to play." (Smith 2009)

4.4.1 The TranSim VS IV™

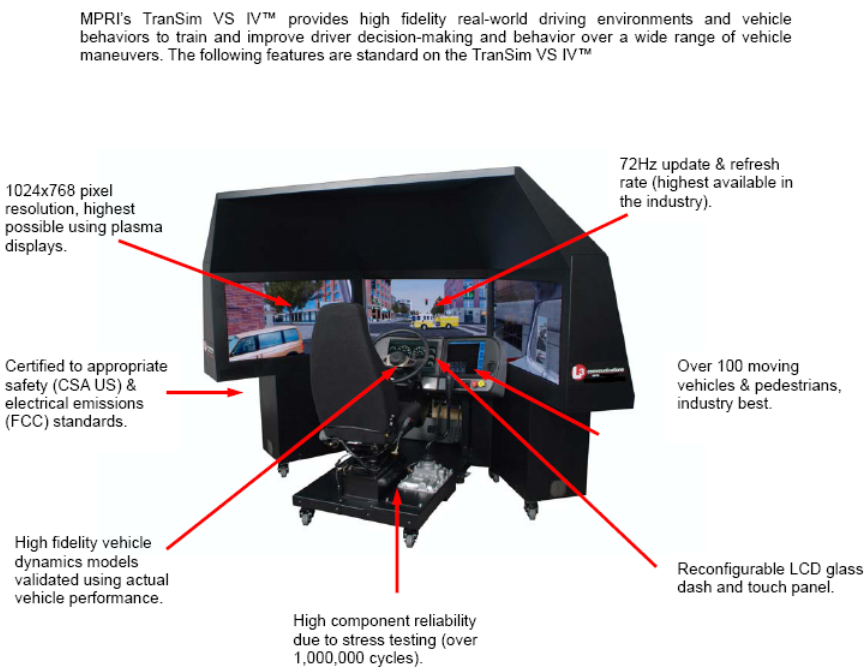
The simulator chosen for this project is the TranSim VS IV™ manufactured by MPRI Simulations Group, a division (based in Salt Lake City, Utah) of the New York company, L-3 Communications. This particular simulator was chosen because it is most likely to be the one the New Zealand transport industry will be introduced to when DECA Training in Auckland bring their new purchase on-line later in 2009.

The industry was first notified that this simulator was on its way by an article in the August 2008 edition of Truck and Driver magazine which stated that;

> "The company (DECA) will introduce a $250,000 US-developed simulator, in which the driver sits in front of three plasma screens, in a truck-like driving setting – with typical driver's seat, steering wheel, gearshift and pedals. The systems' state-of –the-art software means that a variety of driving environments can be played on the screens, a variety of truck dash displays can be replicated and 140 transmissions, 240 engines, 300 tyre sizes and 33 axle ratios can be loaded into the system" (Unknown 2008)

Although this simulator (Figure 5) is designed to play many roles, such as a snow-plough trainer, police squad cars and military applications, the version New Zealand will be seeing first is the truck simulator which, according to MPRI has many features that will allow New Zealand trainers to optimise their training regimes by adding this technology to their arsenals.

Figure 5: TranSim VS IV™ Overview



Source; TranSim VS IV™ Technical Description MPRI Corp

One of this simulator's innovative features is the ability to change the dash panel (Figure 6) to reflect the truck that the trainee is being trained on;

Figure 6: Simulator Glass dash panels

Source; TranSim VS IV™ Technical Description MPRI Corp

Other innovative features include the;

1. "Op-Con Controls" – the interface between the operator and trainee which allows the trainer to select different vehicles, transmissions, scenes, weather, introduce malfunctions such as tyre blowouts and communicate in real time between the instructor and multiple trainees.

Figure 7: Simulator "Op-Con" Controls

Source; TranSim VS IV™ Technical Description MPRI Corp

2. An "After-Action Review Option" which, when combined with the "Replay" feature, allows the trainee to watch what really happened and discuss prevention techniques.

3. A "Scenario Builder" tool (Figure 8) to allow each company to personalise their training on familiar ground or set up a particular scenario for review of an incident.

The TranSim VS IV™ can also be used as an assessment tool for either new employees at the pre-employment stage or for current employees as a prelude to more focused training e.g. fuel management training.

The scoring regime has been designed by ATRI (American Transportation Research Institute) who are currently compiling a Driving Simulator Evaluation;

Figure 8: Scenario Builder Tool

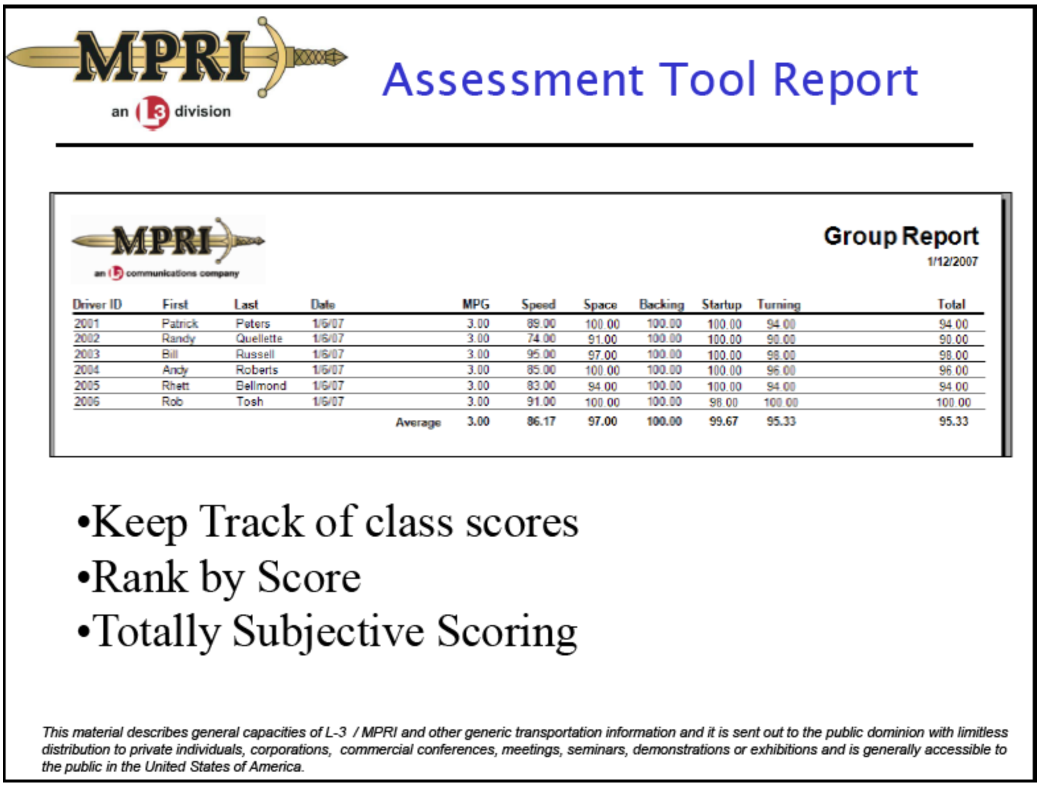
Source; TranSim VS IV™ Technical Description MPRI Corp

"ATRI is presently engaged in a major initiative designed to study the effectiveness of driving simulators in reducing specific driver behaviours that have been linked to future truck crashes. The research couples the findings of the highly influential "Predicting Truck Crash Involvement" study published by

ATRI in late 2005 with an experimental research design utilizing targeted simulator scenarios and testing among a sizeable driver population. ATRI is currently finalizing the simulator scenarios that will be used in the driver testing component of the research. Driver testing is anticipated to begin later this year." (American Transportation Research Institute 2009)

This assessment tool is backed up by a report structure that, while being "totally subjective" will allow 'rank by score' and 'keep track of class scores' as well.

Figure 9: Assessment Tool Report

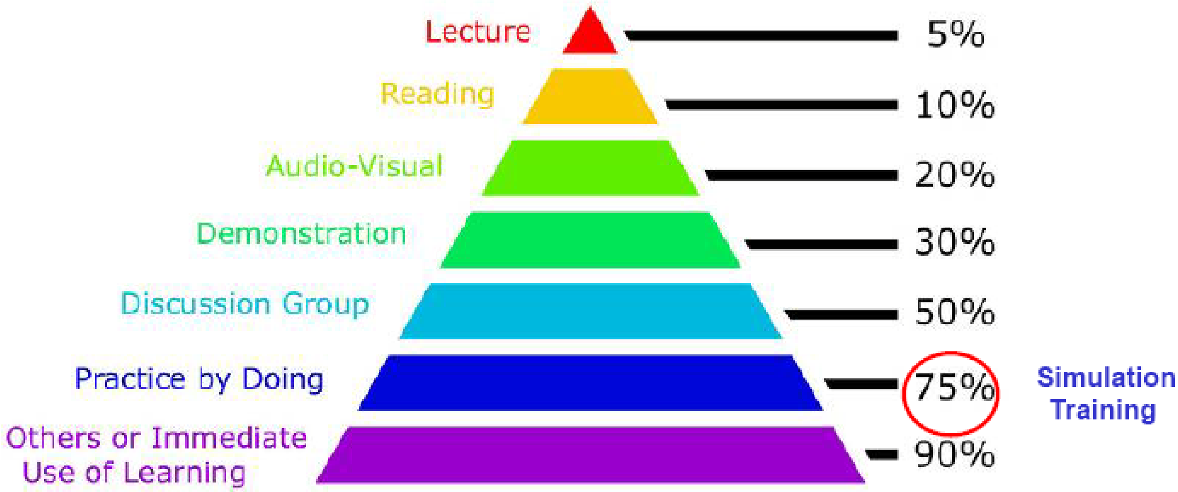


Driver ID	First	Last	Date		MPG	Speed	Space	Backing	Startup	Turning	Total
2001	Patrick	Peters	1/6/07		3.00	89.00	100.00	100.00	100.00	94.00	94.00
2002	Randy	Quellette	1/6/07		3.00	74.00	91.00	100.00	100.00	90.00	90.00
2003	Bill	Russell	1/6/07		3.00	95.00	97.00	100.00	100.00	98.00	98.00
2004	Andy	Roberts	1/6/07		3.00	85.00	100.00	100.00	100.00	96.00	96.00
2005	Rhett	Bellmond	1/6/07		3.00	83.00	94.00	100.00	100.00	94.00	94.00
2006	Rob	Tosh	1/6/07		3.00	91.00	100.00	100.00	98.00	100.00	100.00
				Average	3.00	86.17	97.00	100.00	99.67	95.33	95.33

Source; TranSim VS IV™ Technical Description MPRI Corp

MPRI also use data collected by the National Training Laboratories in Bether, Maine to assert that their technology is more effective at ensuring higher retention rates than other forms of learning. (Figure 10)

Figure 10: Average Learning Retention Rates



Source: National Training Laboratories, Bether, Maine

4.5 Implementation Strategy

It would be prudent for any organisation contemplating operating a simulator in New Zealand to undertake some form of risk analysis.

The structure this might take would vary with the organisation but should include aspects such as the total cost of ownership (TCO).

It would not be sufficient to simply make a buy decision purely on the purchase price alone but rather include the ownership and post-ownership costs as well.

There are three component costs to a TCO;

- Acquisition costs;

These include;

1. Purchase Price Paid
2. Planning Costs
3. Quality Costs
4. Taxes
5. Financing Costs

- Ownership Costs
    1. Risk Costs
    2. Cycle Costs
    3. Conversion Costs
    4. Non-value-added-costs
    5. Supply Network Costs and
- Post Ownership Costs

Whilst all of these parameters may not be necessary in determining whether or not a simulator is an affordable cost risk, many of them will be crucial in the decision making process.

The formula that Hines (2004) uses to determine a TCO can be varied to suit whatever the company requirements may be but the basic structure is;

$$TCO = A + PV \sum_{i=1}^{n} (T_i + O_i + M_i - R_n)$$

where TCO is the total cost of ownership, A the acquisition cost, PV the present value, T_i the training cost in year *i,* O_i the operating cost in year *i,* M_i the maintenance cost in year *i* and R_n the residual value in year *i.* (Hines 2004)

Let's look at some of these issues in more detail. For the simulator in question, as previously mentioned, the purchase price is approximately $US150,000. According to the manufacturer, this includes the cost of the simulator, set-up costs, one week of training for the operators and one year back-up service. (Strong 2009)

If we then factor in costs such as GST at 12.5% on the landed cost, shipping costs, the cost of providing a suitable training infrastructure, what it has already cost in planning and how much the finance charges may be, then what seemed quite a simple exercise has suddenly evolved into a reasonably complex equation. This would also depend on what has been negotiated with the manufacturer beforehand and could or may be included in the invoice/landed price. The one plus in this equation is that, according to the Customs Department, there is no duty payable on this type of equipment. (Customs Department 2009)

4.6 Benefits of Simulator Training

4.6.1 Fuel Efficiency

One of the highest costs in any transport company is the fuel bill and there is ample evidence to suggest that, while there are many ways in which fuel efficiency can be improved, simulator training can be very effective both from the fuel savings aspect and from a cost-benefit basis.

Bison Transport in the USA stated that; "Since the implementation of MPRI simulators in 2002, Bison's annual accumulated safe driving miles for their fleet of 800 trucks have increased by nearly 50 percent, while greater fuel efficiency resulted in annual savings of $770,000. (Bison Transport 2006)

These results are echoed by Schneider National as well;

> "Concerning fuel consumption, the time spent in simulation training offsets behind-the-wheel training and lowers fuel consumption. Simulation results in an average fuel savings of 42 gallons per student, or 335,000 gallons per year.
>
> •Savings Since Mid 2005 = 837,000 gallons
>
> •$$ Saved = $3,766,500
>
> (Based on $4.50 / gallon)"
>
> (Schneider National 2008)

The New Zealand Government has been instrumental in commissioning a research project in 2008 entitled; "Survey on Fuel Efficiency in the Heavy and Light Commercial Vehicle Fleet in New Zealand."

Coyle and Kissling (2009) conclude that;

> "Analysis of the information provided through the interviews indicates that there are several avenues and initiatives that might be followed leading to

improved fuel efficiency in the New Zealand commercial vehicle fleet. These are:

- Driver development programmes mindful of fuel efficient driving techniques
- Adoption of aero-dynamic technology on vehicles
- Greater use of hybrid vehicles
- More electric vehicles except in heavy vehicle fleets
- Better routing of vehicles to eliminate unnecessary kilometres driven
- Better matching of vehicle types to tasks." (Coyle 2009)

Despite there being ample evidence from overseas to suggest that simulator training can improve fuel efficiency across a transport fleet; the report indicates that;

> "There are several factors that inhibit the industry from adopting some of these initiatives. Three primary inhibiters are:
>
> (1) A perceived lack of time to give fuel monitoring and fuel management sufficient attention, which is mostly an internal organisational and prioritisation issue only amenable to subtle external influence.
>
> (2) A lack of knowledge of technologies available and measures that can be taken and what would be their likely impact.
>
> (3) A lack of available authoritative information from trusted sources to overcome lack of technical knowledge that might motivate rethinking of priorities in managing fuel in vehicle fleets." (Coyle 2009)

This lack of knowledge and available information may be what has kept the truck simulator from making an appearance as an added form of training in this field. It is also interesting to note also that when respondents in the survey were asked "How do you think any assistance should be targeted and what form should that assistance take?" 'Best practice Guides' and 'Case Studies' were seen as the most useful but one respondent thought that simulator training would be effective (Table 7).

Table 7: Form and Targeting of Assistance

	Form of Assistance				
Respondent	Best Practice Case Studies	Best Practise Guides	Monitoring Software	Operation Specific Advice	Other
1	●	●	●		simulator training
2	●	●			
3	●	●			
4		●			
5				●	
6		●			Must be simple

Source: Survey on Fuel Efficiency in the Heavy and Light Commercial Vehicle Fleet in New Zealand pg 27.

Perhaps if more detailed research is done as to the effects of simulator training with regard to fuel savings and more information is readily available, then possibly, more informed decisions can then be made.

4.6.2 Safety Awareness and Training Time Reduction

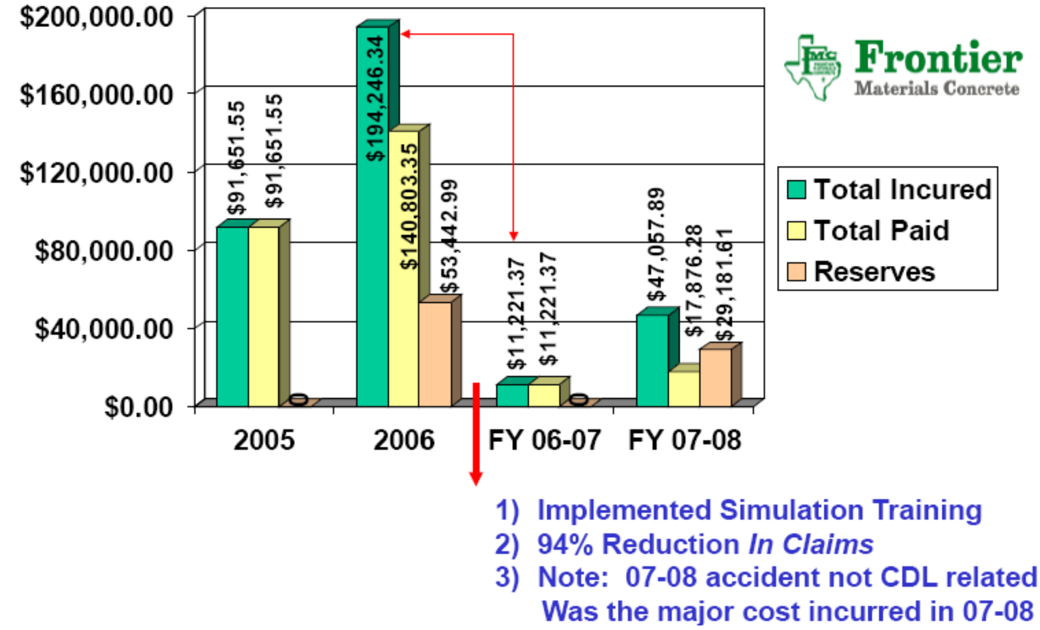
There is empirical evidence that simulator training can reduce training time and increase safety awareness among employees.

Rawe (2007), Director Risk Control Services for United Rentals Inc said; “In 2007 United Rentals trained 8000 CDL & non-CDL drivers using MPRI’s Space Management curriculum course, resulting in an overall 42% accident reduction rate.” (Rawe 2007)

Similar results were indicated by Streuber (2006), President and CEO of Bison Transport; “We have seen an 83 percent improvement in meantime between incidents after simulator training for preventable accidents —these results speak for themselves.” (Streuber 2006)

Frontier Materials Concrete introduced simulator training in 2006 and recorded a 94% reduction in accident claims for the year 2006-2007.

Table 8: Frontier Materials Accident Claim Amounts



Source: MPRI Audiovisual Presentation pg 37

4.7 The Disadvantages

One of the main disadvantages of any simulator, be it an aircraft simulator or a truck simulator, is the question of "Simulator Adaptation Syndrome" (SAS).

Wikipedia has this description;

> "Simulator Adaptation Syndrome ("SAS"), is an issue with all simulators, not just driving simulators. The main causes of Simulator Adaptation Syndrome are system delays between the driver's command and the response of the simulator. In effect the brain, referencing driving a real vehicle, expects the simulator's response to be the same as a car, the greater the deviation the greater the "adaption burden" on the brain.
>
> If the deviation is large, the driver may experience symptoms of headaches, motion sickness, disorientation, etc due to SAS although this is very

> dependent on the individual. Likewise the simulator "cues" also have an effect that is some individuals will experience discomfort due to a simulator not having motion cues, where others may not have a problem with such simulators. Some individuals will show high tolerance to visual system delays, where others may not". (Wikipedia 2009)

This form of motion sickness was first researched by Havron and Butler (1957) and was documented in a helicopter simulator. (Casali 1986, August).

Kolasinski (1995) reported that;

> "Although there is debate as to the exact cause or causes of simulator sickness, a primary suspected cause is inconsistent information about body orientation and motion received by the different senses, known as the cue conflict theory. For example, the visual system may perceive that the body is moving rapidly, while the vestibular system perceives that the body is stationary. Inconsistent, non-natural information within a single sense has also been prominent among suggested causes. Although a large contingent of researchers believe the cue conflict theory explains simulator sickness, an alternative theory was reviewed as well". (Kolasinski 1995)

Kolasinski further defined the condition as

> "Similar to motion sickness, but can occur without actual motion of the subject" and categorised the symptoms as "The most common symptoms resemble those of motion sickness: general discomfort, apathy, drowsiness, headache, disorientation, fatigue, pallor, sweating, salivation, stomach awareness, nausea, and vomiting. Postural instability, flashbacks (a sudden recurrence of symptoms), retching, and vomiting have also been known to occur". (Kolasinski 1995)

Because of the complex symptoms that SAS manifests Kennedy and Fowlkes (1993) suggest that ‘Simulator Sickness’ should be more appropriately termed a ‘syndrome’(Kennedy 1993)

While this condition can be a very real threat to the efficient uptake of any training conducted in the simulator, MPRI have developed a system of adapting trainees to the simulator by;

> “Preparing drivers beforehand to focus mentally on specific tasks to be completed in each training experience. At the same time, the simulator scenarios should be limited to those specific tasks for which the simulator can provide effective cueing fidelity.” (Unknown 2009)

5.0 Prospective New Zealand Customer Study

5.1 Introduction

A questionnaire (Appendix A) was circulated among the transport companies with which the author has regular contact to ascertain their understanding of simulator technology, its uses and relevance to them as a training tool.

This survey was designed to establish, first, if training is done and whether this is done “in-house” or by a training provider and whether or not to National Certificate level. They were also asked if they would prefer that any training conducted was to Unit Standard quality.

The next stage was to ascertain whether there is an awareness of the existence of simulators and their capabilities.

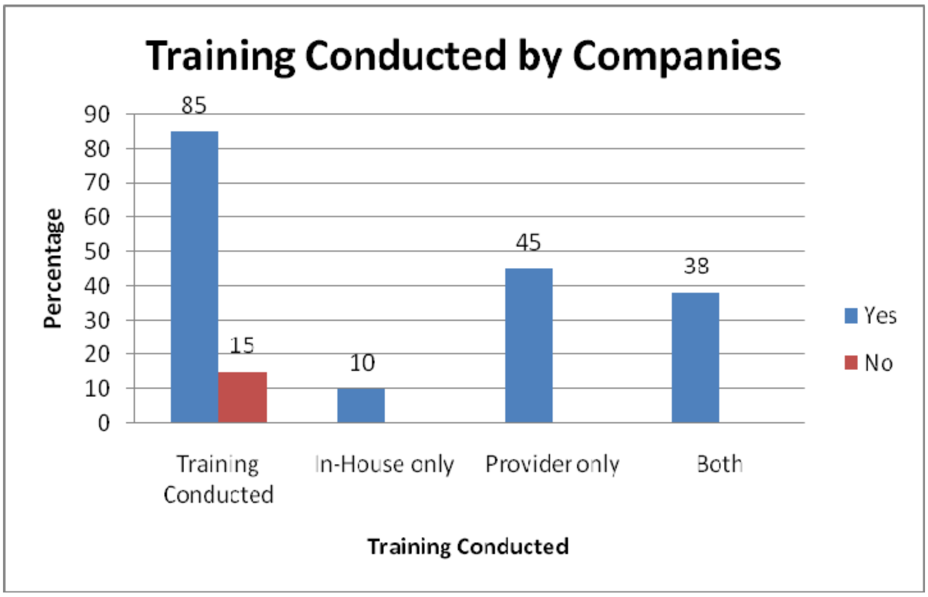
Further questions were asked to see if companies were prepared to send staff away to a simulator if it were in a fixed location, with all the associated costs of travel accommodation etc., or whether they would prefer the simulator to come to them, i.e. be mobile and whether or not they thought they might expect to pay more or less for this technology.

It must be noted that this survey cannot be, by its nature, a statistically robust sample as this is beyond the ambit of this dissertation but it is designed to gather useful feedback from industry. Conclusions drawn from this survey can only be tentative but could become the focus of future research.

5.2 Analysis

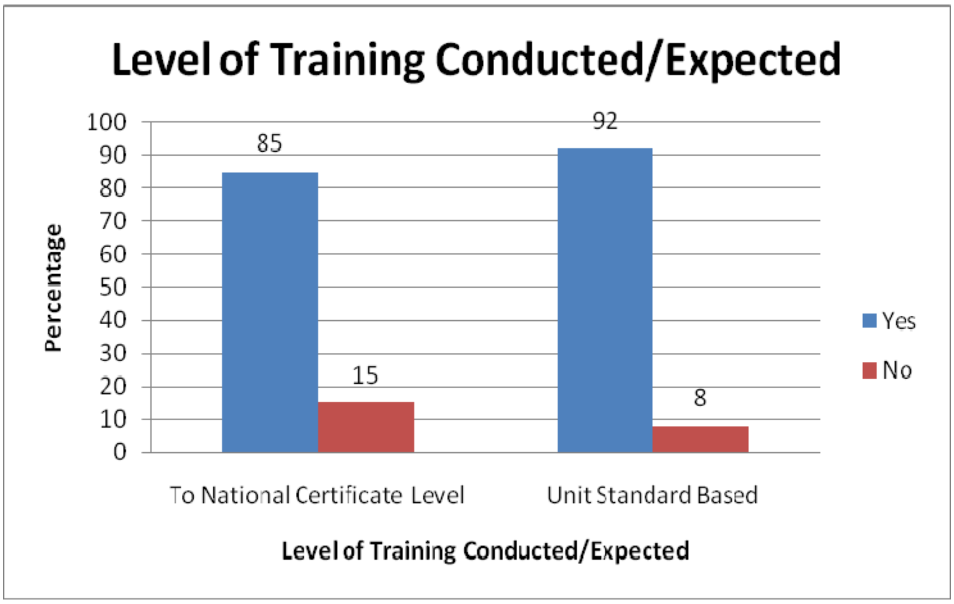
This proved quite interesting as results showed that 85% of companies surveyed already conducted some form of training with their heavy vehicle fleet and this was broken up into 45% using training providers exclusively, only 10% doing all their own training and 38% using a mixture of both. This mixture varied from 25% to 90% own training and between 50% and 75% for provider training.

Figure 11: Training Conducted by Companies



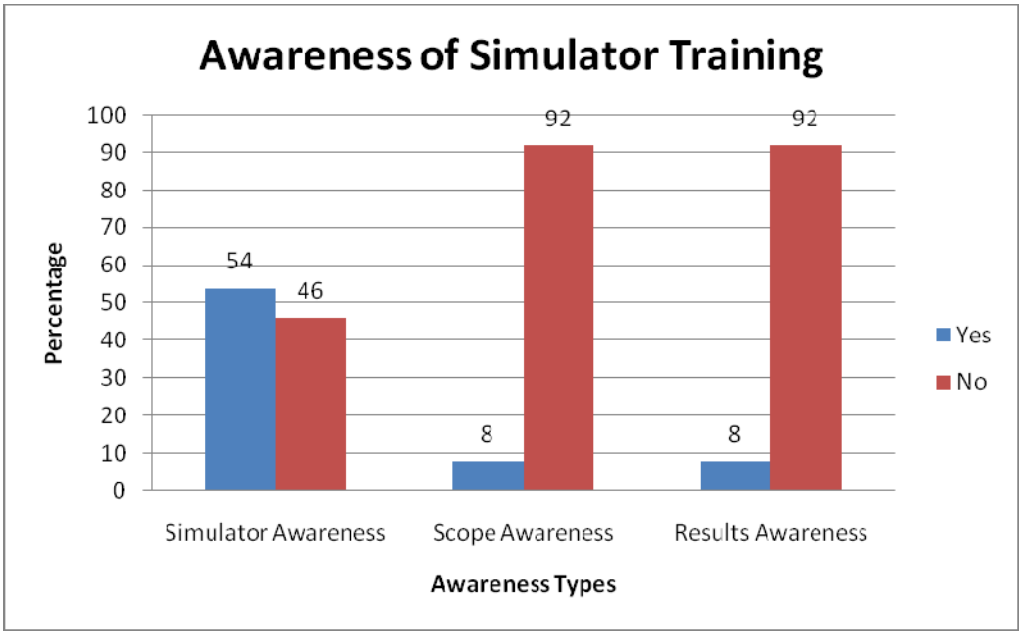
A large percentage of companies trained to National Certificate level (85%) and an even larger proportion would prefer that any simulator training was Unit Standard based (92%).

Figure 12: Level of Training Conducted/Expected



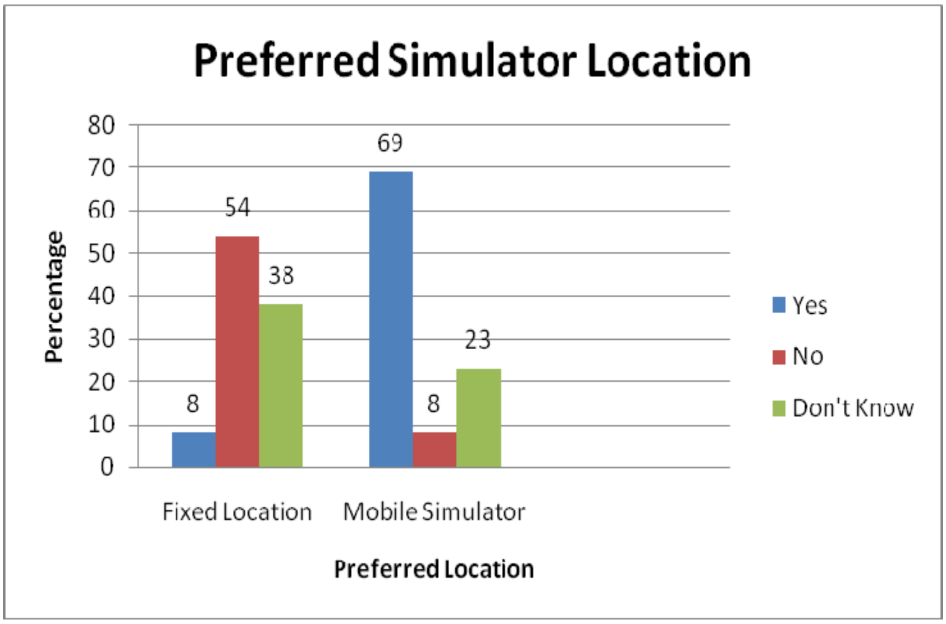
While there were similar numbers showing an awareness of the availability of simulators for training purposes (54% aware and 46% not aware) there was a considerably larger disparity in knowledge of what the available scope of simulator training is and the results that are available if simulator training were undertaken;

Figure 13: Awareness of Simulator Training



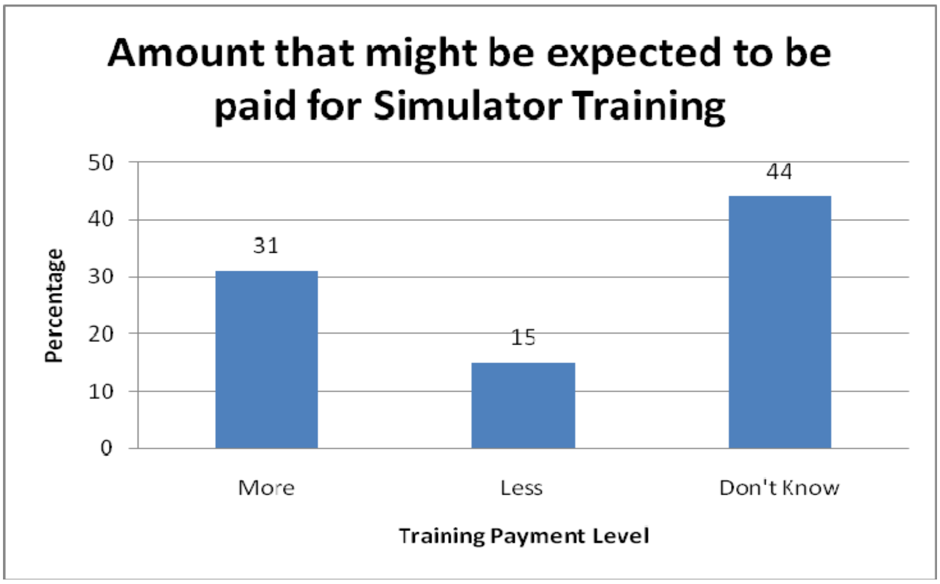
As to whether a company would send staff to a simulator or would prefer the simulator to come to them, the fixed location attracted a ‘No’ vote of 54% with only 8% saying they would move staff to the training. The ‘Don’t Know’ proportion of 38% reduced significantly to 23% with the subsequent rise in the percentage saying they would prefer the simulator to come to them.

Figure 14: Preferred Simulator Location



Interestingly, the percentage of companies that might expect to pay more for this technology was noted at 34% and those that might expect to pay less was 15%. As this technology is a relative unknown in New Zealand it is not surprising to see the “Don’t Know’s” at 44%.

Figure 15: Amount that might be expected to be paid for Simulator Training



5.3 Unit Standard Relevance

If simulator training is introduced to New Zealand and the results are to be quantified in any realistic way then some form of acceptable measurement of the training outcomes must be introduced. While the simulator already mentioned in this dissertation produces its own reports these would need to be placed into some form of measurable and comparative context. One way of achieving this could be in the form of one or more Unit Standards.

While this can be a time consuming process, the basis for developing these Unit Standards exists through the New Zealand Qualifications Authority and the relevant Industry training Organisations (ITO).

A draft Unit Standard which addresses some of these techniques in conjunction with appropriate classroom training is attached at Appendix B. It draws on currently available "hands-on" training and is modified to meet the needs of introducing simulator training to an existing regime. This could be easily expanded to include whatever aspect of training could be incorporated into simulator training.

5.4 Summary

These results indicate that there is a general awareness of the existence of the truck simulator as a training tool but not of the scope and the results available from this form of training.

Although most of the companies surveyed undertook some form of training, it will take far more in-depth research to establish what specific training needs might be met by simulator training and, indeed, whether they are willing to utilise this form of training.

Most companies indicated a preference for any simulator training to be Unit Standard based and this is in line with the number that train to National Certificate level.

There was a definite preference for the simulator to be able to travel and the one the author saw in Australia was mobile as is the one DECA intend to bring into New Zealand. (See

Section 2.4) (Stubbs 2008) and a perception that this form of training could be expected to cost more than the traditional one-on-one training currently used.

Given the level of awareness, the level of training currently undertaken and a perceived willingness to use this technology if it were available in the regions, it could be concluded that there will be an uptake of this form of training should it be introduced. Even if there were a price increase for this training it would appear that this would still be the case.

Further detailed market research should be a priority of any training firm wishing to set up this technology and once the hardware is operational, it is essential that follow up research be done investigating its effectiveness.

6.0 Conclusions

6.1 Introduction

This dissertation set out to;

1. Establish the framework of how a HV driver is trained in NZ and what the different routes are by which licensing of these drivers is achieved and compare this to overseas licensing regimes.
2. Establish what, if any, training is required to meet these legislative requirements both in New Zealand and overseas.
3. Establish the benefits (or not) of introducing this technology into NZ from a training point of view.
4. Look at results obtained in overseas research as to the benefits in operational safety achieved by simulator training and how this might be incorporated into current or future legislative and/or training requirements in NZ.
5. Survey prospective New Zealand customers as to their understanding of simulator technology, its uses and relevance to them as a training tool.

6.2 Driver Licensing

Section 4.3 sets out the current thinking as far as driver licensing is concerned in New Zealand, Australia and Europe. It is quite disturbing that both here and in Australia it is so simple to progress through the licensing system and not really receive any substantial training at all before being put in charge of 44 tonnes of truck and cargo (soon to rise to 53 tonnes). This is worse in Australia as some loaded trucks can weigh upwards of 65 tonnes. Whether or not simulator training can make a substantial difference to this situation will take a change of legislation to allow simulator training to become a normal part of the licensing regime as proposed in Europe.(EU Commission 2001).

6.3 Operational Aspects

This technology has several advantages;

1. Less downtime for vehicles,
2. The ability to simulate emergencies
3. The ability to create and re-create scenarios again and again

While there is also evidence from overseas that a truck simulator can be of benefit to the trainer and the transport company employing the technology in the fields of fuel economy, better driving skills and accident avoidance, there is as yet no empirical evidence in New Zealand simply because the technology does not exist here.

There has been interest shown by government and some sections of the training industry to the point where there will be a simulator in New Zealand in the near future. Judging by the level of awareness from within industry, and having an awareness of this industry's tendencies to do things 'the way they've always been done', it will be interesting to see what the uptake might be when the simulator finally comes available.

The technology is proven overseas to work but as was noted in section 2.6 (The Trainer) there is still much work to be done both with the training providers and the transport companies to ensure acceptance at all levels of these advancements.

Even though these advances should make heavy vehicle training more effective, there will always be a place for the trainer being in the vehicle with the driver, one-on-one, if there is to be any advanced training delivered.

There is much scope for extended research on this subject and when the simulator finally makes its appearance in the heavy vehicle training paradigm the opportunities for this research will open up.

This dissertation serves to open these doors by raising the awareness of the technology at as many levels as possible to allow reasoned discussion and proper cost-benefit analyses to be conducted.

The author is certain that once we see the simulator up and running and awareness is generated about just how useful an addition this tool is to the trainer's suite of tools, we will see renewed interest by all sections of industry and government.

To answer the question posed by this dissertation "Is the Truck Simulator a (suitable) training option for the heavy vehicle industry?" the answer would be a qualified 'yes'. However, there is much work to be done before this technology becomes an accepted part of the wider transport and training industries.

6.4 Recommendations

There is a need for industry and training providers to ensure that, once a simulator is operational in New Zealand, all aspects of its performance are fully documented and these results (bearing in mind commercial sensitivity) are made available to the wider training and operational communities.

If this is not done then the benefits that are available will not be realised and any acceptance will be made more difficult.

It is essential that industry in conjunction with the ITO's and NZQA ensure there is a quantifiable result recording and qualification system in place.

Consultation should be underway now between these bodies to set up an Industry Advisory Group (IAG) to begin the formalisation process. One suggested draft Unit Standard is shown in Appendix B of this paper and this could be expanded easily to form a suite of relevant qualifications that would allow formal measuring of the outcomes from any training regime set up by the provider(s) that will offer this technology to industry.

As this technology becomes available in New Zealand there will be many opportunities for further research into how the benefits may be exploited to suit the ever-changing needs of New Zealand's transport industry to ensure our future in a globally competitive environment.

Appendix A

Questionnaire to NZ transport companies

1. Does your company currently conduct heavy vehicle driver training?

Yes / No

If "Yes", then is the training;

a. In-house i.e. use your own trainers

Yes / No

b. Use contract training providers

Yes / No

c. Mix of both a and b.

Yes / No a: _____ % b:_____ %

d. To National Certificate level

Yes / No /Don't know

2. Is your company aware of the use of truck simulators for training?

Yes / No

3. Is your company aware of the scope of training available with simulators?

Yes / No

4. Are you aware of what results a simulator is capable of achieving?

Yes / No

5. If a simulator was available in New Zealand would your company send your drivers to the simulator for training if;

a. The simulator was in a fixed location.

Yes / No / Don't know

b. If the simulator was mobile and could travel to your area.

Yes / No / Don't know

6. If your company decided to use a simulator for all or part of your training, would you expect the training to be Unit Standard based?

Yes / No / Don't know

Company: ___________________________________

Type of business: _____________________________

Number of employees: _________________________

I give permission for this data to be incorporated into a Master's Dissertation to be submitted through Lincoln University, New Zealand by Craig Luxmoore on the grounds that this data will not be used for any other purpose.

Name: ____________________________ Signature: _______________________

Company Position: __________________ Date: ___________________________

Appendix B

Draft Unit Standard to "Demonstrate safe and efficient driving techniques in a heavy combination motor vehicle simulator".

Level TBA

Credits TBA

Purpose	This unit standard recognises the skills and knowledge beyond those required to obtain a full Class 5 driver licence. People credited with this unit standard are able to: explain factors that influence safe and efficient driving; explain the operating characteristics of heavy combination motor vehicle systems in relation to safe and efficient driving; and demonstrate safe and efficient driving techniques in a heavy combination motor vehicle simulator.

Subfield	Commercial Road Transport
Domain	TBA
Status	Proposed
Status date	dd MMMM yyyy
Date version published	dd MMMM yyyy
Planned review date	dd MMMM yyyy
Entry information	Open
Replacement information	This unit standard replaced unit standard nnnnn. [Only appears if populated.]
Accreditation	Evaluation of documentation and visit by NZQA and industry.
Standard setting body (SSB)	Name of SSB

Accreditation and Moderation Action Plan (AMAP) reference nnnn

This AMAP can be accessed at http://www.nzqa.govt.nz/framework/search/index.do.

Special notes

1 Legal requirements to be complied with include:
Health and Safety in Employment Act 1992;
Heavy Motor Vehicle Regulations 1974;
Land Transport Act 1998;
Land Transport (Driver Licensing) Rule 1999;
Land Transport (Road User) Rule 2004.

2 Any new, amended, or replacement Acts, regulations, Rules, standards, codes of practice or Land Transport New Zealand requirements or conditions affecting the outcome of this unit standard will take precedence for assessment purposes, pending review of this unit standard.

3 Definitions
Defensive driving means the use of driving techniques that enable a driver to maintain safe control of the vehicle despite the actions of others and the prevailing driving environment;
Drive means to operate or to use the vehicle on a road and includes all the tasks associated with driving such as pre-use and post-use procedures;
Dynamics of a heavy combination vehicle means the motion of the vehicle, and the interaction of the various physical forces that affect that motion;
A *hazard* is anything that is, or has the potential to be, dangerous to the operation of the vehicle, its load, or other road users;
Efficient driving means using driving techniques that ensure that vehicle movements are completed in a timely manner and are fuel efficient;
Safe driving includes driving without contact with obstacles; injury to persons or animals; damage to property or the environment, facilities and/or freight; in a manner that is courteous to other road users; in compliance with the law; and within the limits of the vehicle and road dimensions;
Space management is the control of a safe operating space around a vehicle and includes the application of the four and twelve second rules;
Speed management means appropriate control of vehicle speed for the prevailing driving conditions and includes compliance with posted speed limits;
Straight line reversing requires the driver to reverse the vehicle in a straight line for a minimum distance of four vehicle lengths with minimal steering inputs to maintain the straight line;

The *system of vehicle control* is a way of approaching and negotiating hazards that is methodical, safe, and leaves nothing to chance.

4 Practical driving assessments are to be conducted in a heavy combination goods service vehicle simulator. The simulator is to be operated in urban and highway environments in three periods of at least (TBA) each, with one period simulating the hours of darkness.

5 Industry health and safety guidelines are contained in *Guide to Health and Safety in Road Transport* (Wellington; Accident Compensation Corporation, November 2004), available at http://www.acc.co.nz or from the Road Transport Forum NZ, PO Box 1778, Wellington.

Elements and performance criteria

Element 1
Explain factors that influence safe and efficient driving.

Performance criteria

1.1 The explanation includes driver factors that influence safe driving.

Range: includes but is not limited to – driver attitude, fatigue management, compliance with driving hours rules, driver health including sleep deprivation and disorders, non-work related activities, use of prescription and non-prescription drugs, use of alcohol, drink-driving, medical condition, driver familiarisation with the vehicle, vehicle pre-use and en route checks.

1.2 The explanation includes vehicle factors that influence safe driving.

Range: includes but is not limited to – design, dynamics (both laden and unladen), stability, maintenance.

1.3 The explanation includes driving techniques in terms of their contribution to safe and efficient driving.

Range: includes but is not limited to – the system of vehicle control, speed management, space management, hazard detection, operation of vehicle controls, night driving, route planning, courtesy to other road users, cornering techniques, progressive shifting, braking, management of power, fuel efficiency.

1.4 The explanation includes the relationships between defensive driving, fuel efficient driving, crash reduction and repair and maintenance costs.

1.5 The explanation includes the impact of motor vehicle crashes on personal and financial situations.

Range: includes but is not limited to – driver, families, other road users, the economy of New Zealand, own organisation, customers, the road transport industry.

1.6 The explanation includes the impact of internal vehicle distractions and hazards on safe and efficient driving.

Range: includes but is not limited to – passengers, fitted equipment, temperature control, seating posture, vehicle cab housekeeping.

1.7 The explanation includes procedures to couple and uncouple a heavy trailer to a prime mover safely.

Range: any two of – full trailer, pole trailer, semi-trailer.

Element 2
Explain the operating characteristics of heavy combination motor vehicle systems in relation to safe and efficient driving.

Performance criteria

2.1 Types of engines are explained in terms of efficient vehicle operation.

Range: electronic, non-electronic.

2.2 Types of transmission are explained in terms of efficient operation and vehicle control.

Range: manually operated constant mesh non-synchromesh, automated constant mesh non-synchromesh, synchromesh, fully automatic.

2.3 Traction control systems are explained in terms of safe vehicle control.

Range: includes but is not limited to – differential locks, anti-skid reduction.

2.4 Types of brakes and braking systems are explained in terms of vehicle performance, handling, and safe driving.

Range: includes but is not limited to – disc, drum, anti-lock, auxiliary braking systems;
auxiliary braking systems include – exhaust, engine, hydraulic, electro-magnetic.

2.5 The explanation of braking system maintenance requirements is in accordance with manufacturer’s specifications and includes the effect of braking system maintenance on safe driving practice.

Range: includes but is not limited to – draining of air tanks, brake adjustment.

2.6 The explanation includes common suspension types in terms of vehicle dynamics.

Range: includes but is not limited to – air, leaf spring.

element 3

Demonstrate safe and efficient driving techniques in a heavy combination motor vehicle simulator

Range: tractor unit with one of – full trailer, pole trailer, semi-trailer.

performance criteria

3.1 Driving techniques used demonstrate safe and efficient driving.

Range: includes but is not limited to – the system of vehicle control, cornering techniques, speed management, space management, hazard detection, operation of vehicle controls, night driving, route planning, courtesy to other road users, progressive shifting, braking, parking, management of engine power, negotiating ascents and descents.

3.2 Driving techniques used are consistent with the condition of the vehicle and its load in terms of safe and efficient driving.

Range: includes but is not limited to – the operating characteristics of the vehicle, vehicle stability, the driving environment, the physical in-cab environment.

3.3 Management of internal vehicle hazards and distractions ensures that driver focus remains on safe and efficient driving.

3.4 Vehicle is reversed safely and in a fuel efficient manner.

Range: to a predetermined point, in a straight line, to the left.

Please note

Providers must be accredited by NZQA, or an inter-institutional body with delegated authority for quality assurance, before they can report credits from assessment against unit standards or deliver courses of study leading to that assessment.

Industry Training Organisations must be accredited by NZQA before they can register credits from assessment against unit standards.

Accredited providers and Industry Training Organisations assessing against unit standards must engage with the moderation system that applies to those standards.

Accreditation requirements and an outline of the moderation system that applies to this standard are outlined in the Accreditation and Moderation Action Plan (AMAP). The AMAP also includes useful information about special requirements for organisations wishing to develop education and training programmes, such as minimum qualifications for tutors and assessors, and special resource requirements.

Comments on this unit standard

Please contact the SSB ssb@email.address if you wish to suggest changes to the content of this unit standard.

7.0 References

Allen, T. and R. Tarr (2005). Driving simulators for commercial truck drivers-humans in the loop.

American Transportation Research Institute. (2009). Retrieved 25 June 2009, from http://www.atri-online.org/index.php?option=com_content&view=article&id=51&Itemid=62.

Baas, P. (2003). "*Fleet Driver Safety*, AA 2003 Driver Education Conference, Wellington New Zealand, April 2003."

Baas, P., Latto, D (2005). "Heavy Vehicle Efficiency."

Bison Transport (2006). "Press Release May 16, 2006."

Blana, E. (1996). "*A Survey of Driving Research Simulators Around the World,* Institute of Transport Studies, University of Leeds, Working Paper 481."

Brock, J. F., Jacobs, C.M., McCauley, M. (2001). "TCRP Report 72: Simulators and Bus Safety: Guidelines for Acquiring and Using Transit Bus Operator Driving Simulators. TRB, The National Academies, Washington, D.C., 2001."

Brown, P. (Unknown). from http://www.nzfirst.org.nz/policies/transport.php.

Career Services. (2008). "Heavy Truck Driver - Job Outlook." Retrieved 25 Feb 2009, from http://www.careers.govt.nz/default.aspx?id0=61103&id1=J80298.

Casali, J. G. (1986, August). "Vehicular simulation-induced sickness, Volume 1: An overview. IEOR Technical Report No. 8501. (NTSC TR 86-010). Orlando, FL: Naval Training Systems Center. Casali, J."

Central Area Road Transport Association Inc (2009). Update: Immediate and Long Term Shortage Lists. November 2009 Occupational Shortages Review. CARTA News July 2009**:** pg. 14.

Chisholm, S. L., Caird, J.K., Lockhart, J.A., Vacha, N.H., Edwards, C.J., (2008). "*Do In-Vehicle Advance Signs Benefit Older and Younger Driver Intersection Performance?* University of Calgary, Calgary, Alberta, Canada." International Journal of Human-Computer Studies, Vol 66, Issue 3, March 2008, pgs 132-144.

Christie, R. (2000). "Driver Licensing Requirements and Performance Standards Including Driver and Rider Training."

Coyle, M. (2009). "Personal email communication, 08 January 2009."

Coyle, M., . Kissling, C (2009). Report on a Survey of Key Influencers, Fleet Operators, and Drivers of Heavy and Light Commercial Vehicles in New Zealand to Ascertain the Practices, Attitudes, Perceptions and Barriers to Change in Relation to Introducing Fuel Efficiency Interventions, Christchurch, 2009.

Customs Department (2009). Instruments, apparatus and models, designed for demonstrational purposes (for example, in education or exhibitions), unsuitable for other uses. Section XV111 Chapter 90/9. Number 9023.00.00.00K.

de Hamel, W. (2008). 20 January 2009, from http://www.simdrive.co.nz/index.html.

Department of Labour. (2008). "Skill Shortages: Occupations in Shortage in New Zealand. Survey of Employers who have Recently Advertised (SERA) 2007." Retrieved 25 January 2009, from http://www.dol.govt.nz/PDFs/jvm-shortage2007.pdf.

Duynhoven, H. (2008). Personal communication, 30 December 2008.

EU Commission (2001). Proposal for a Directive of the European Parliament and of the Council
the training of professional drivers for the carriage of goods and passengers by road. COM (2001) European Parliament (2003) PE 330.876 (op.cit. p27).

European Parliament (2003 pg24). "PE 330.876 pg 24."

Evans, K. (2009). "Collective Agreement, Taranaki. 1 Nov 2009 - 31 Oct 2010. Downer EDI Works."

Furneaux, J. (2009). Email communication 20 Aug 2009, C. Luxmoore.

Gianutsos, R., Zencius, A. H.,Lane, I.,Wesolowski, M. D. (1991). "Cognitive rehabilitation: A neuropsychological speciality comes of age." Brain Injury **5**(4): 353-368.

Hines, T. (2004). Supply Chain Srategies; Customer-driven and customer-focused.

Kennedy, R. S., Fowlkes, J. E., & Lilienthal, M. G. (1993). "Postural and performance changes following exposures to flight simulators. ." Aviation, Space, and Environmental Medicine, 64(10), 912-920.

Kolasinski, E. M. (1995). "Simulator Sickness in Virtual Environments. ."

Labour Government. (1996). "New Zealand Government Executive Coalition Agreement, Policy Area; Transport." Retrieved 20 Dec 2008, from http://executive.govt.nz/96-99/coalition/transpo.htm.

Ministry of Transport (2007). Land Transport (Driver Licensing) Rule 1999**:** pgs 26 - 32.

Ministry of Transport. (2008). Retrieved 22 October 2009, from http://www.transport.govt.nz/research/Pages/CostestimatesPart1-TheSocialCostofRoadCrashesandInjuries.aspx.

Ministry of Transport. (2009). "Land Transport (Driver Licensing) Rule1999." Retrieved 22 September 2009, from http://www.legislation.govt.nz/regulation/public/1999/0100/latest/DLM280562.html.

Morrison, J. E. (1991). "Training for performance: principles of applied human learning." Wiley.

National Road Safety Committee (2006). "Road Safety Education Strategic Framework."

New Zealand Transport Agency (2008). Statement of approval Conditions. Governing the delivery of NZ Transport Agency approved driver licensing courses.

New Zealand Transport Agency. (2009). from http://www.nzta.govt.nz/.

Newell, D. (Unknown). MPRI Audiovisual Presentation.

Olsen, E. C. B. (1995, August.). The evolution of a virtual reality driving simulator: From law enforcement training to research and assessment. Proceedings of the Third Annual International Conference: Virtual Reality and Persons with Disabilities., California State University, Northridge: Center on Disabilities.

Parkes, A. M. (2003). Truck Driving using simulation in England.

Parkes, A. M. and H. J. Rau (2004). "An Evaluation of Simulation as a Viable Tool for Truck Driver Training."

Parkes, A. M., Rau, H.J. (2004 b). "An Evaluation of Simulation as a Viable Tool for Truck Driver Training." ITEC 2004 pg 9.

Precision Training Ltd. (2008). Retrieved November 2008, from http://www.precisiontraining.co.nz/pdf/Media_releaseSI.pdf.

Queensland Government (1999). Transport Operations (Road Use Management — Driver Licensing) Regulation 1999, s 9(6)(b)(ii). Queensland Transport.

Rawe, H. (2007). MPRI Presentation pg 38, Auckland 16 April 2009.

Road Safety Discussion Forum. (2006). Retrieved 04 January 2009, from http://www.safeas.govt.nz/smf/index.php?action=printpage;topic=117.0.

Roberts, K. M. (1980). "The FHWA highway driving simulator. Public Roads 44(3)."

Schneider National (2008). "MPRI Presentation pg 32."

Skellern, G. (2008). $200,000 drives poly to centre of transport expertise. Bay of Plenty Times 15 Dec 2008. Tauranga.

Smith, W. (2009). Email communication Monday 15 June 2009. C. Luxmoore.

Statistics Department. (2008). Retrieved 25 Feb 2009, from http://www.stats.govt.nz/products-and-services/table-builder/table-builder-business.htm.

Strayer, D. L., .Drews, Frank A. (2002). "Simulator Training Improves Driver Efficiency: Transfer from the Simulator to the Real World. Department of Psychology 380 S. 1530 E. Rm 502 University of Utah Salt Lake City, UT 84112, USA)."

Streuber, D. (2006). MPRI Audivisual Presentation pg 63, Auckland, 16 April 2009.

Strong, B. (2009). Personal conversation with Byron Strong, International Sales Manager MPRI. 24 April 2009.

Stubbs, S. (2008). from http://www.precisiontraining.co.nz/pdf/Media_releaseSI.pdf.

Stubbs, S. (2009). Personal conversation 05 January 2009.

TERNZ (2006). "Transport Engineering Research New Zealand Limited (TERNZ), Driver Recruitment/Retention in the Heavy Truck Transport Industry 2005/06 Update."

Tranzqual. (2009). Retrieved 22 October 2009, from http://www.tranzqual.org.nz/about-us/.

Unknown (2008). Driver trainer expands...Gets simulator. Truck and Driver. **August 2008:** pg 7.

Unknown (2009). Simulator Adaptation Syndrome Topic Paper. Courtesy MPRI, Gold Coast, Australia, 24 April 2009.

Waikato University. (2008). from http://www.waikato.ac.nz/wfass/subjects/psychology/research/driver-sim/tars-profile.shtml.

Wierwille, W. W. and P. P. Fung (1975). "Comparison of computer-generated and simulated motion picture displays in a driving simulator. Human factors 17(6). pp 577-90."

Wikepedia. (2009a). "Heads Up Display." Retrieved 22 February 2009, from http://en.wikipedia.org/wiki/Head-up_display.

Wikipedia. (2009). "Driving Simulator." from http://en.wikipedia.org/wiki/Driving_simulator.

William Collins Sons & Co Ltd (1988). "The Collins Dictionary and Thesaurus."

Yoshimoto, K., Suetomi, T. (2008). "The History of Research and Development of Driving Simulators in Japan." Journal of Mechanical Systems for Transportation and Logistics **1**(2): 159-169.